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APPLIED MECHANICS REVIEWS

VOL. 11, NO. 2 MARTIN GOLAND *Editor* FEBRUARY 1958

AERODYNAMIC HEATING

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INTRODUCTION

AERODYNAMIC heating refers to the heating of a body as a result of its motion through a gaseous medium. Specifically, the heating has two sources: (a) friction in the gas as it moves past the body, and (b) compression of the gas at forward stagnation regions of the body. Consequently, the vehicle becomes covered with a layer of hot gas whose heat is then available for transfer into the body. Since the temperature of this layer of hot gas increases with the square of the speed of the vehicle, it follows that serious temperature problems are incurred very rapidly. In fact, aerodynamic heating becomes significant in structural design at Mach number three when the temperature at a stagnation region reaches about 600 F.

The problem of aerodynamic heating is rather new, incurred by modern supersonic flight, whether with cruising and gliding missiles supported by the atmosphere or with ballistic missiles and space vehicles entering the atmosphere. Basically, the problem is to determine the rate of heat transfer into the surface of the aircraft. This means that the region of the flowing gas near the surface (boundary layer) must be analyzed to investigate the ability of the gas to transfer the heat generated by dissipation or compression. Furthermore, owing to the high aerodynamic temperatures at extreme speeds, it is necessary to know what kind of air one is dealing with, because at temperatures of about 2500 F (corresponding to Mach number six) the perfect-gas air molecules begin to vibrate, and at about 5000 F (corresponding to about Mach number 10) the molecules begin to dissociate and even ionize. The calculation of heat transfer under such real gas conditions then becomes very difficult, because the thermodynamic as well as the transport properties of the gas have changed. A review of the moderate-supersonic aerodynamic-heating problem was given by the writer (1).* General considerations for hypersonic flight were presented by Bond (2), and equilibrium conditions in real gases behind normal shocks in the atmosphere were calculated by Feldman (3) based on properties tabulated by Hilsenrath and Beckett of the National Bureau of Standards (4). The complete problem must of course take into account the structural design, since the heating rate depends upon the temperature of the structure which in turn depends upon the heat absorbed by the structure. Novel or unconventional designs may be necessary to solve the heat problem, including internal cooling of sandwich structures and transpiration (sweat) cooling.

The rate of heat transfer on blunt surfaces (perpendicular to the flow) or flat surfaces (parallel to the flow) depends upon whether the flow adjacent to a body is laminar or turbulent. With regard to heat transfer, it is desired to keep the flow laminar, because the heat-transfer rate with laminar flow can be an order of magnitude less than for turbulent flow. For this reason, the control of transition from laminar to turbulent flow is a subject of intensive research (5).

*Numbers in parentheses refer to the references at the end of the paper.

HEAT TRANSFER CALCULATION

Flat Plates

The rate of heat transfer q_w from a hot friction layer to a flat plate moving at high speed in the direction of the plate is calculated from the modified Newtonian law

$$q_w = c_{H\delta}\rho_\delta u_\delta (i_r - i_w) \qquad [1]$$

in which ρ_δ and u_δ are the fluid density and velocity at the outer edge of the boundary layer, respectively, and i_r and i_w are the recovery and wall enthalpies, respectively. The dimensionless coefficient $c_{H\delta}$ is called the Stanton number. The recovery enthalpy is usually written in terms of a recovery factor r in

$$i_r = i_\delta + r \cdot u_\delta^2/2 \qquad [2]$$

The Stanton number c_H and the recovery factor r can be computed upon simultaneous solution of the momentum and energy equations for the boundary layer.

For laminar flow with zero pressure gradient, a solution for $c_{H\delta}$ was carried out by Kármán and Tsien (6) for the case c_p = constant, $Pr = 1$, and $\mu \sim T^{0.76}$. Here Pr is the Prandtl number defined by $c_p\mu/k$, where c_p is specific heat at constant pressure, μ is coefficient of viscosity, and k is coefficient of thermal conductivity. T is absolute temperature. When the Prandtl number is unity, the recovery factor is always unity. A physically more complete analysis was performed by Crocco (7) who assumed arbitrary constant Prandtl number near unity and Sutherland viscosity law. Further detailed results using Crocco's analysis are available in an *NACA Technical Note* by the writer (8). The general results of these works show that the Stanton number decreases with increase in flight Mach number, but increases with cooling. The recovery factor is found to be approximately equal to $Pr^{1/2}$. The solution was further refined by the writer to include variable Prandtl number (9); although r was also found to be a function of i_w, nevertheless, for engineering purposes $r = Pr_\delta^{1/2}$, where δ signifies the property at the outer edge of the boundary layer.

Owing to its complexity, the turbulent boundary layer does not lend itself readily to exact solution as does the laminar layer. Rather, semi-empirical mixing-length methods are used

(10, 11), computing first the local friction coefficient defined by $c_{f_\delta} = 2\tau/\rho_\delta u_\delta^2$, and then calculating the Stanton number from the modified Reynolds analogy, $c_{H_\delta} = c_{f_\delta}/2\,Pr^{2/3}$. The compressible-flow analysis began with the suggestion of Kármán (12) that wall conditions ρ_w and μ_w apply all the way across the boundary layer; therefore that wall conditions could be substituted into the existing incompressible-flow friction formula to obtain $c_{f_w} = 2\tau/\rho_u u_\delta^2$ and then converted to free-stream conditions to get the local friction coefficient from $c_{f_\delta} = c_{f_w}\rho_w/\rho_\delta$. A later treatment by Cope (13) went one step further than Kármán and substituted the incompressible-flow velocity profile, in terms of wall conditions, into the Kármán compressible-flow momentum integral to get c_{f_δ} directly, allowing the density to vary according to the Crocco velocity-temperature relation

$$\frac{T}{T_\delta} = \frac{T_w}{T_\delta} - \left(\frac{T_w}{T_\delta} - 1\right)\frac{u}{u_\delta} + \frac{\gamma - 1}{2}\cdot M_\delta^2 \cdot \frac{u}{u_\delta}\left(1 - \frac{u}{u_\delta}\right) \quad [3]$$

Here, u is the velocity in the boundary layer corresponding to temperature T, u_δ the free-stream velocity corresponding to T_δ, T_w the wall temperature, M_δ the free-stream Mach number, and γ the ratio of the specific heats at constant pressure and constant volume. Finally (10), a theory was developed in which the density was allowed to vary in the original Prandtl mixing-length shear formula, and a compressible-flow velocity profile was derived for use in the compressible-flow momentum integral. The results of these analyses are: (a) increasing Mach number is relatively more effective in decreasing heat transfer in turbulent flow than in laminar flow, and (b) cooling also increases the heat-transfer coefficient as with laminar flow. These results have been well confirmed experimentally (14, 15). For turbulent flow, r can be approximated by $Pr^{1/3}$ (see Ref. 11).

Blunt Bodies

With flat plates (or cones), the aerodynamic heating is very much greater at the leading edge (or point) than downstream, owing to the fact that the hot friction layer is thinner (i.e., closer to the surface) there. To alleviate this excessive heating, the noses of bodies and the leading edges of wings may be rounded (blunted), because by so doing the thermal boundary layer may be maintained sufficiently thick to limit the heat transfer. Furthermore, blunting of a nose or a leading edge increases the ratio of contained volume to surface area, thus providing a means of absorbing more readily the heat input. In the vicinity of the stagnation point the flow is expected to be laminar because of the low Reynolds numbers there.

In supersonic flight of a blunt body, the details (i.e., density and velocity) of the flow region between the bow shock wave and the body are not known exactly, and for this reason the aerodynamic heating problem on the face of a blunt body has not lent itself to exact solution. Also the new kind of dissociated and ionized air brought about by high temperature behind the shock wave has new thermodynamic and transport properties that complicate the solution. Nevertheless, a reasonable solution can be arrived at by using an incompressible-flow formula in the stagnation region where the flow is subsonic. The incompressible solutions by Sibulkin (16) for spheres and by Squire (17) for cylinders are therefore written in terms of local conditions just outside the boundary layer and finally, if desired, transformed to undisturbed conditions in front of the shock. For spheres the formula for heat transfer in an incompressible stagnation region is, in terms of local conditions,

$$q_w = \frac{0.763\,Pr^{-0.6}}{\sqrt{\rho_\delta u_\delta x/\mu_\delta}}\cdot\rho_\delta u_\delta (i_r - i_w) \quad [4]$$

where x is measured along the surface from the stagnation point, and δ still signifies conditions at the outer edge of the boundary layer which in fact starts from the stagnation point with finite thickness. For cylinders the constant is 0.570. In the stagnation region, i_r is obtained from

$$i_r = i_\infty + u_\infty^2/2 \quad [5]$$

which holds for adiabatic flow across the shock. It is interesting to note that Eq. [4] for heat transfer in a falling pressure field has the same form as the Blasius solution for flow on a flat plate with constant pressure, viz.,

$$q_w = \frac{0.332\,Pr^{-2/3}}{\sqrt{\rho_\delta u_\delta x/\mu_\delta}}\cdot\rho_\delta u_\delta (i_r - i_w) \quad [6]$$

The factor $0.332\,Pr^{-2/3}$ in Eq. [6] is different from $0.763\,Pr^{-0.6}$ in Eq. [4] because of the different internal velocity and temperature profiles in the two types of flow. In spite of the similarity of Eqs. [4] and [6], the proper external velocity fields must be inserted in the equations in order to make the correct heat-transfer calculations. Thus in Eq. [6] u_δ = constant, whereas in Eq. [4], $u_\delta = \beta x$, where, for supersonic speeds, β depends only upon the Mach number, changing, according to experiment by Korobkin (18), from approximately $2\,u_\infty/D$ for $M_\infty = 1$ to nearly u_∞/D at speeds above $M_\infty = 5$. The subscript ∞ refers to undisturbed conditions before the shock and D is the diameter of curvature of the body at the stagnation region. The heat-transfer rate measured experimentally by Stine and Wanlass (19) on the face of a sphere at Mach number two has substantiated the incompressible-flow assumption underlying Eq. [4]. At hypersonic speeds above Mach 10, the new real (dissociated, ionized) air which exists behind the bow shock should be introduced in Eq. [4]. (i_r is still obtained from Eq. [5]; thus i_r is independent of dissociation.) Stagnation-point heat-transfer measurements (20) in shock tubes simulating flight conditions at velocities up to 26,000 fps again verify the incompressible-flow assumption within reasonable accuracy. A more refined procedure (21) taking into account diffusion and recombination does not appear to yield much different results when compared with experiment (21). The reader will find it interesting that the results with dissociation are not greatly different from those which one might compute assuming a perfect gas. In fact, the heat-transfer rate with dissociation begins to deviate gradually from the perfect-gas solution at Mach number six to only thirty per cent greater than the perfect-gas solution at Mach number 20.

Although the heat-transfer rate in the vicinity of stagnation can be generally computed assuming laminar flow, it is possible that the flow will become turbulent just off the stagnation region, because of the rapid increase of the local Reynolds number there, and therefore turbulent heating rates could occur over an appreciable part of the face of blunt bodies at high body Reynolds numbers. This is of course not good, because such turbulent heating builds up quickly with distance (as $x^{3/5}$), reaching a maximum at about 45° from the stagnation point and having, for example, a value of the order of 5 times the laminar stagnation rate when $\rho_\infty u_\infty D/\mu_\infty \approx 10^7$. An elementary turbulent-flow theory for the stagnation vicinity, assuming a 1/7-power velocity profile and local incompressible flow (behind the shock), yields the following result for spheres (1, 22):

$$q_w = \frac{0.042\,Pr^{-2/3}}{(\rho_\delta u_\delta x/\mu_\delta)^{1/5}}\cdot\rho_\delta u_\delta (i_r - i_w) \quad [7]$$

For cylinders, the constant is 0.040. Again, $u_\delta = \beta x$. Also, it is noted that Eq. [7] has the same form as the turbulent incompressible-flow flat-plate formula whose constant is 0.030. While dissociation will have some influence on the turbulent heat-transfer rate, its effect again will not be great (23).

TRANSITION

The phenomenon of transition from laminar to turbulent flow in the region near the wall is not sufficiently understood to permit prediction of its occurrence. However, linearized theory shows that boundary layers may be stabilized by (a) accelerating the flow with falling pressure in the direction of motion (24, 25) and (b) cooling the boundary layer at the surface of the body (26, 27). Since transition results from unstable flow, the above methods should also delay transition. The laminar-flow wing (28) has provided experimental justification of the stabilizing effect of falling pressure, and the experiments of Boison and the writer (29) have verified the delay of transition of cooling. Nevertheless, caution must be exercised in applying these transition-delaying devices, because, if overdone, acceleration and cooling could expose submerged surface roughnesses and bring about a reversal in transition. The latter possibility has already been observed (29).

While the delay of transition by cooling applies to smooth walls and low free-stream turbulence, certainly, as is expected, an increase in roughness or free-stream turbulence lessens that delay. However, it has been found experimentally (29) that the effects of both roughness and turbulence in promoting transition decrease as Mach number increases; also that transition can still be delayed by cooling depending upon the size of the roughness.

An interesting criterion for minimum transition Reynolds number, obtained from observation of turbulent pipe-friction data, is $\rho(\tau/\rho)^{1/2} \cdot \delta/\mu = 60$, to be applied to the laminar boundary layer (23). This is a criterion for minimum transition on a smooth body caused by free-stream turbulence. When applied to the Blasius case of flat-plate flow, the criterion yields for transition Reynolds number $\rho u_g x/\mu = 160{,}000$; for the stagnation region of a sphere, it gives $\rho u_g \theta/\mu = 150$, where θ is the momentum thickness. For artificial promotion of transition with roughness, it is also found from pipe data that for earliest possible promotion it is necessary that $u_g/(\tau/\rho)^{1/2} \cdot \rho(\tau/\rho)^{1/2} \cdot k/\mu = \rho u_g k/\mu = 540$, where k is roughness height equal to boundary layer thickness δ.

MASS TRANSFER

Excessive aerodynamic heating on the face of a blunt body or leading surface of a wing can be alleviated by transferring mass, such as steam, helium, or liquid water through the surface into the flow field. When a gas is transferred, the process is called blowing; when a liquid is transferred, the process is called transpiration or film cooling. Mass transfer would be particularly useful in case of turbulent flow. Indeed, in applying mass transfer, turbulent flow should be assumed, because mass transfer promotes transition. When turbulent flow is assumed, a theoretical analysis (30) shows that, at Mach number 10, a blowing rate of steam, varying like the turbulent no-blowing heating rate over the face of a body and having a maximum of about 3% of the local mass flux just outside the boundary layer, will hold the maximum turbulent heating rate down to the theoretical laminar stagnation value. Future ultra-high-speed glide missiles or re-entry sections may well utilize mass-transfer systems to protect their leading surfaces from the aerodynamic heat.

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"Letters to the Editor" and "Books Received for Review" now appear after the reviews.

Theoretical and Experimental Methods

(See also Revs. 483, 517, 521, 539, 587, 597, 621, 660, 663, 680, 689, 694, 704, 706)

Book—359. Southwell, R. V., Relaxation methods in theoretical physics, New York, Oxford University Press; Vol. I, 1946, vii + 248 pp. $5.60; Vol. II, 1956, vii + 272 pp. $8.80.

Relaxation methods are already widely known, largely because the first volume of this work preceded the second by ten years. Together, the two volumes develop the method of "systematic relaxation of constraints", applied to problems involving two or three independent variables. The book presents, in the words of the author, "the position attained by the end of 1955" in research on relaxational solution of problems in field of physics.

In relaxation, a finite-difference relation between values of the wanted function at nodal points of a regular net is substituted for the differential equation describing a phenomenon. The essential feature is the formulation of this relation in terms of a "residual", representing an imagined constraint at a representative nodal point; all residuals are zero when the relation is satisfied everywhere. From the governing equation is also constructed an operator showing the change in the residuals produced by a unit increment to one of the nodal values of the wanted function. Starting with any assumed distribution of the wanted function, and fixing attention on the residuals, these are systematically reduced (practically) to zero by use of the operator. The computer's physical intuition and mathematical skill are continuously in action to hasten liquidation of the residuals.

Volume I develops the relaxational treatment of plane-potential problems, conformal transformations, and quasi-plane-harmonic equations. Volume II treats biharmonic, eigenvalue, and nonlinear problems, and summarizes recent extensions to three-dimensional and "marching" problems. Problems in which (a) the location of boundaries or interfaces is not initially known or (b) different equations govern in different parts of the domain are shown to be tractable.

This is the definitive work on relaxation methods in theoretical physics. Setting forth the complete product of the relaxationist school, it presents the results of many researchers. Nevertheless, the mark of the leader is clearly to be seen throughout; the author, who originated the method (except for the less general moment-distribution of Hardy Cross), remains the central figure of the group that has developed and explored its possibilities. The book is not for the beginner; simpler explanations of the basic techniques of relaxation are available. For the serious student it is indispensable. Nowhere else is there a similarly exhaustive treatment of the theory and applications of relaxation methods.

C. H. Walther, USA

360. Barta, J., Modification of Vianello's iteration method (in German), *Acta Techn. Hung. Budapest* **17,** 3/4, 341–347, 1957.

Paper discusses Vianello's method, by means of which the critical value of the compressive force of a bar may be computed. The modification proposed in this paper substitutes the solution of initial-value problems for the solution of boundary-value problems in each step of the iteration. The convergency of the process is proved. From author's summary

361. Ostrowski, A., An approximation solution of systems of homogenous linear equations (in German), *ZAMP* **8,** 4, 280–285, July 1957.

Author shows that the equation $S\zeta = 0$, where S is an $n \times n$ matrix with zero determinant, can be solved approximately by $\xi/|\xi|$, where ξ is a solution of the equation $(S + A)\xi = \eta$, where η is a given (arbitrarily chosen) vector and A a matrix whose elements a_{ij} are small. The error of the solution $\xi/|\xi|$ is of the order $[\Sigma_{ij} |a_{ij}|^2]^{1/2}$. Some consequences of this theorem are discussed. D. ter Haar, England

362. Krasovskii, N. N., On the conditions required for the application of the theorem of A. M. Lyapunov on instability to stationary systems of differential equations (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **101,** 1, 17–20, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5714.

This is a brief account of results published earlier by the author. In addition, the following theorem is put forward:

Suppose the existence of function v, assuming in any smaller area at will around point 0 a neutral value, and such that in the area round 0

$$dy/dt = 0 \text{ on } H \qquad dv/dt > 0 \text{ outside } H$$

where H is region round sound area of point 0.

If H does not contain positive semitragectories distinguishable from zero, then the solution $x_1 = \ldots = x_n = 0$ of the equation $dx_i/dt = X_i(x_1, \ldots, x_n)$ $(i = 1, \ldots n)$ is not stable.

Courtesy Referativnyi Zhurnal V. I. Zubov, USSR
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363. Albrecht, J., Difference method in parabolic differential equations (in German), *ZAMM* **37,** 5/6, 202–212, May/June 1957.

Finite difference solution for parabolic differential equations is illustrated by the heat conduction problem to examine the stability and accuracy of the method and its dependence on the choices of time interval and lattice points. H. Lin, USA

364. Moon, P., and Spencer, D. E., Errors in the solution of integral equations, *J. Franklin Inst.* **264,** 1, 29–41, July 1957.

A method of obtaining solutions of the Fredholm integral equation by exponential approximation of the kernel is described, and an estimate is given of the accuracy of the approximate solution. Improved accuracy can be obtained by adding the solution of an auxiliary equation to the approximate solution where the magnitudes involved in the auxiliary equation are only a few per cent of the original quantities.

The results are applied to interflections in cylindrical blackbodies, and the errors are evaluated for previous solutions of the problem. A. R. Mitchell, Scotland

365. McLeod, J. H., and Leger, R. M., Combined analog and digital systems—why, when, and how, *Instrum. and Automat.* **30,** 6, 1127–1130, June 1957.

Detailed analysis of the largest combined analog-digital system yet undertaken gives qualitative and quantitative answers to the basic questions of why, when, and how such combined systems should be used. From authors' summary

366. Atkinson, C. P., Superharmonic oscillations as solutions to Duffing's equation as solved by an electronic differential analyzer, ASME Summer Conf. Berkeley, Calif., June 1957. Pap. 57-APM-45, 6 pp.

Paper presents the experimental response curves for the solutions of Duffing's equation for that frequency range where higher-order harmonics (called superharmonics as opposed to lower-order or subharmonics) of the fundamental are important components of the solution. The experimental results were obtained by solving Duffing's equation on an electronic differential analyzer. Corroboration of analytical results is presented for the third-order superharmonic component of solutions which were calculated by a two-term Ritz approximation. The results of this paper indicate that superharmonics of higher order than the third, that is, fifth and seventh order, and even-order harmonics such as second and fourth order can be found in the frequency range studied. Author points out a definite relationship which exists between the superharmonic generated and the free-vibration curve ("backbone") of the system. For example, if the maximum displacement of the solution containing an nth order superharmonic is compared with the same amplitude of the free-vibration curve, it is seen that the

frequency of the fundamental (the forcing frequency) is $1/n$ times this natural frequency or, conversely, the frequency of the superharmonic component is n times that of the fundamental and has, in fact, the frequency of the free vibration for that amplitude. Thus a superharmonic of order n can be pictured as a sustained free vibration which is generated when the frequency of the forcing function is $1/n$ of the frequency of the free-vibration response curve. The phenomenon of superharmonic oscillations is pictured here as a nonlinear resonance. Experimental evidence of the superharmonic-jump phenomenon as discovered analytically by John Burgess also is presented.

From author's summary

367. Symposium on automatic coding, Jan. 24-25, 1957; Philadelphia, Pa., J. Franklin Inst., Monograph no. 3, Apr. 1957, 118 pp.

Eight papers presented at the symposium, along with discussion on them, are included. Automatic programming is the most hopeful technique for overcoming the difficulties and expense of preparing problems for electronic computers; consequently, this report of systems already in operation is timely and valuable. The first paper, "Automatic coding at G. E." by R. M. Peterson, describes routines used at the Univac installation in Louisville, including sort and merge generators, the generalized programming (G.P.) system, and an automatic report-publishing system. The next paper, "Systems of debugging automatic coding" by C. Katz, discusses the problem of providing a programmer, using an automatic system, with sufficient information to correct errors in his code. "Print I—an Automatic coding system for the IBM 705," by R. W. Bemer, illustrates how a machine designed primarily for business applications can be used equally well on scientific problems. "The procedure translator" by H. Kinzler and P. M. Moskowitz describes the B-O compiler for Univac, once the notation has been carefully defined, as it must be for any automatic system; it offers a method of expressing flow diagrams of business operations in ordinary English statements, and then converting the statements automatically into machine code. "Omnicode," presented by R. McGee, was originally proposed for the IBM 702, but actually written for the IBM 650, and illustrates how an automatic programming language can be made independent of any particular computer. L. C. McGinn in "Matrix compiler for Univac" describes an assembly of programs for carrying out a sequence of matrix operations. The next paper, "A mathematical language compiler" by A. J. Perlis and J. W. Smith, is on a system, which has been widely distributed, written for the Datatron 205 and the IBM 650. Once problems have been expressed in the formal language of flow diagrams and iterations, as introduced by Goldstine and Von Neumann, the computer translates the result into a working machine code. In the final paper, "A mechanized approach to automatic coding," E. C. Yowell describes how many of the facilities of automatic programming have been built into the hardware of the National Cash Register 304 computer, without complicating the machine design to an unreasonable extent.

C. C. Gotlieb, Canada

368. Bauer, F. L., Contribution to the development of numerical methods of program-controlled computers II. Direct factorization of polynomials (in German), *S. B. Math.-nat. Kl. bay. Akad. Wiss.* 163-203, 1956.

Present paper is a continuation of part I [title source 1954, pp. 275-303]. In latter paper interest was centered upon second-order convergence methods for the determination of roots of polynomials. This is also the subject of another paper by the author [see AMR **9**, Rev. 3818].

Present work is concerned with factorization of polynomials. Two iterative procedures are defined. The pertinent equations are too long to be reproduced here, but the idea is an extension of the technique first given by Bernoulli. Except under unusual circumstances, the procedure is linearly convergent. Author claims procedure is especially advantageous for high-speed computers. Paper suffers from a lack of numerical examples.

Y. L. Luke, USA

Digital application series; *14 parts covering the selection and application of data processing equipment and systems,* CONTROL ENGINEERING.

369. Grabbe, E. M., Data processing systems: how they are used, 2, 12, 40-45, Dec. 1955.

370. Carr, J. W., III, Solving scientific problems, 3, 1, 63-70, Jan. 1956.

371. Carr, J. W., III, A comparison of large-scale calculators, 3, 2, 84-92, Feb. 1956.

372. Carr, J. W., III, Small-scale computers as scientific calculators, 3, 3, 99-104, Mar. 1956.

373. Wegstein, J. H., and Alexander, S. N., Programming scientific calculators, 3, 5, 87-92, May 1956.

374. Adams, C. W., Processing business data, 3, 6, 105-112, June 1956.

375. Gibbons, J., Let's look at the available business-data processors, 3, 7, 101-112, July 1956.

376. Hopper, Grace M., Programming business-data processors, 3, 10, 101-106, Oct. 1956.

377. Salzer, J. M., Controlling a process, 3, 12, 95-100, Dec. 1956.

378. Gimpel, D. J., Sampled-data systems, 4, 2, 99-106, 1957. 1957.

379. Bower, G. G., Analog-to-digital converters: what ones are available and how they are used, 4, 4, 107-116, Apr. 1957.

380. Phister, M., Jr., and Grabbe, E. M., Fitting the digital computer into process control, 4, 6, 129-136, June 1957.

381. Gibbons, J., How input/output units affect data-processor performance, 4, 7, 97-102, July 1957.

382. Ragland, E. A., and Wassall, D. E., The digital answer to data telemetering, 4, 7, 95-101, Aug. 1957.

Book—383. McDowell, C. H., A short dictionary of mathematics, New York, Philosophical Library, 1957, xiii + 104 pp. $2.75.

This book of 104 pages contains about 64 pages of information and 40 pages of padding. It is divided into two sections, one on arithmetic and algebra and the other on plane trigonometry and geometry. Definitions are fully duplicated instead of being cross-referenced, and reviewer considers even this to be unnecessary for many terms. For instance "complex fraction" and "fraction complex" are both recorded and fully defined. Again "Logarithms, Brigg's; common; or decimal" are each defined and referred to the other two, and many other terms similarly. Many terms defined fall into the field of accountancy, not mathematics. Finally, four pages of signs, symbols, etc. are duplicated at the end of each section.

There are too many misprints; for instance, complex numbers and imaginary numbers are defined with reference to i where

$i^2 = 1$ or $\sqrt{1} = i$, both of course wrong. In the definition of "probability," 3/29 appears for 5/29. There are notable gaps in the terms chosen for definition. For example, two terms defined with reference to a third are "tensor" and "vector" in Quaternions, which are not mentioned. The denary and duodenary scales of notation are defined but not the binary scale which is of major importance in modern computing. Again the numerical value of "e" is given, but not the series from which it is derived.

Reviewer does not agree with many of the definitions and considers them either too loose or even incorrect; e.g., a "billion" in U.K. is a million million and in U.S.A. a thousand million. Definition gives the first with note that some people call a thousand million a billion. The definitions of ellipse, parabola, hyperbola, parameter (principal) rider, subnormal, and subtangent are too loose to be considered correct. The paper used for the book is very inferior, the standard of printing is by no means good, and the price is at least an order too high. Book is not one that the reviewer would recommend.

A. F. W. Langford, So. Australia

384. Richman, E., and Elmaghraby, S., The design of in-process storage facilities, *J. Indust. Engng.* **8,** 1, 7–9, Jan.–Feb. 1957.

After a short discussion of the importance of in-process storage facilities in production-line operations, authors attempt to apply queue theory to a simple problem (five stages, all with the same service time). The attempt fails. The results obtained assume that the input rate decreases as one moves down the production line (in this case a bottling plant). Burke [*Operat. Res.* **4,** p. 699, 1956] has shown that, in a multistage series queue system, the input rate is constant (and the distribution remains Poisson) for each stage. The storage requirements would then be the same between any two stages instead of decreasing from 13 to 4, as suggested by the authors.

Before "proceeding to more sophisticated mathematical models," a review of Burke's article will show that the naive approach suggested by the authors will yield some valid preliminary results, even when the stages are not in balance.

E. Koenigsberg, USA

Mechanics (Dynamics, Statics, Kinematics)

(See Revs. 395, 426, 459, 681, 711)

Servomechanisms, Governors, Gyroscopics

(See Revs. 377, 380, 583, 660)

Vibrations, Balancing

(See also Revs. 589, 602, 617, 714, 717)

385. Braunbek, W., Forced vibrations of a simple nonlinear system. Pt. I, The differential equations and their stationary solutions (in German), *Z. Phys.* **147,** 297–306, 1957.

Paper deals with forced periodic vibrations of a system of one degree of freedom, with cubic restoring force (Duffing's system), with and without damping. Discussion is detailed but differs little from that to be found in many textbooks on vibrations [e.g., N. W McLachlan, "Ordinary nonlinear differential equations in engineering and physical sciences," Oxford 1950, pp. 57–62].

R. Drenick, USA

386. Braunbek, W., and Sauter, E., Forced vibrations of a simple nonlinear system. Pt. II, Transient movement (in German), *Z. Phys.* **147,** 507–519, 1957.

Paper is a continuation of paper of preceding review and deals with the aperiodic response of a vibrating system of one degree of freedom, with cubic restoring force (Duffing's system), with and without damping. Method of slowly varying phase and amplitude is used. Discussion is detailed of the undamped case, and somewhat cursory of the damped case.

Reviewer considers this study to have been largely anticipated, and more attractively treated, by C. Hayaski [AMR **6,** Rev. 3317; also in greater detail in the book by the same author: "Forced oscillations in nonlinear systems," Nippon Printing and Publishing Co., Osaka, 1953].

R. Drenick, USA

387. Handelman, G., and Tu, Y.-O., Antisymmetric vibrations of a beam, *J. appl. Mech.* **24,** 2, 312–313, June 1957.

388. Nepomnyashchii, E. A., Forced oscillations of a loosely fastened elastic bar (in Russian), *Tekhn. informatsiya po regul'tatam nauch.-isled. rabot Leningr. lesotekhn. Akad.* no. 23, 41–45, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6192.

An investigation is carried out on the forced linear transverse oscillation of a bar with a fixed end in the transverse direction, capable of displacement without rotation.

A. F. Rozhnyatovskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

389. Mahalingam, S., Transverse vibrations of power transmission chains, *J. appl. Phys.* **28,** 4, 145–149, Apr. 1957.

The natural frequencies of a travelling chain are determined by treating the chain as a uniform string. For a constant chain tension the natural frequencies decrease progressively to zero as the chain speed approaches the velocity of transverse wave propagation. In practice such a condition is not obtained since the chain tension increases with speed owing to centrifugal effects. Formulas are obtained for the amplitude of forced vibration of the chain when excited by a transverse displacement at one end. The effect of damping is considered, and exact and approximate methods of determining resonant amplitudes are given.

From author's summary by A. G. Sharp, USA

390. Chen, H. S. G., Note on the principal frequencies of a double spring-mass system, *Amer. J. Phys.* **25,** 5, 311–312, May 1957.

Paper gives an algebraic solution for the principal frequencies of a double spring-mass system. A comparison of numerical results is given.

From author's summary

391. Clark, C. B., Vibrating spring experiment, *Amer. J. Phys.* **25,** 5, 322–323, May 1957.

392. Haskins, J. F., and Walsh, J. S., Vibrations of ferroelectric cylindrical shells with transverse isotropy. I. Radially polarized, *J. acoust. Soc. Amer.* **29,** 6, 729–734, June 1957.

Expressions for the coupled mechanical vibrations and electrical admittance of ferroelectric tubes having transverse isotropy are derived and the results supported with experimental data. Coupled modes in radially polarized barium titanate tubes are examined as a function of length-to-radius ratio. A frequency-dependent expression is given for the admittance in terms of electromechanical coupling, capacitance, and tube length. Results permit close prediction of resonant frequencies. An optimum length-to-radius ratio of 2.9 is indicated for maximum electromechanical coupling with the gravest radial mode in a radially polarized tube.

From authors' summary

393. Kumai, T., The effect of loading conditions on the natural frequency of hull vibrations, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **5,** 17, 9–20, 1957.

During the past years Kumai has published several papers on ship vibration. His most important contribution is probably the calculation of natural frequencies of higher modes by means of shear deflection. Present paper is merely a rough estimation of the difference between the first mode (two nodes) vertical and horizontal vibration frequencies for loaded and ballasted ships. He arrives at the following mean ratios between these frequencies:

Type of vessel	Type of vibration	Ratio between frequencies in loaded and ballasted c.
Tankers	Vertical	1.07
	Horizontal	1.11
Dry cargo ships	Vertical	0.97
	Horizontal	1.045

The figures may be useful for predesign estimation. Approximations of this type, if they are reasonably accurate, are of great practical value, because full-ship vibration calculations are so involved that they are very rarely carried out, and, if they are made, the result will be available too late to influence, say, the decision of engine revolutions. G. Vedeler, Norway

394. Heinrich, G., Vibration of tubes through which liquids flow (in German), *ZAMM* **36,** 11/12, 417–427, Nov./Dec. 1956.

Paper deals with small transverse vibrations of cylindrical tubes through which a liquid is flowing. The wave propagation—which is anisotropic—is studied in detail for a nondispersive system in the form of a "string with flow." For dealing with the free oscillations of such a system fixed at two points, a graphic as well as an analytic method is given.

From author's summary by M. Botman, Canada

Wave Motion in Solids, Impact

(See also Revs. 468, 478, 481, 482)

395. Eringen, A. C., Elasto-dynamic problem concerning the spherical cavity, *Quart. J. Mech. appl. Math.* **10,** 3, 257–290, Aug. 1957.

Paper presents solution to important problem of general case of arbitrary loading of a spherical cavity in space and in time. Fourier transform techniques are used. Special cases concisely treated are: (1) Zero surface shear; (2) normal traction with central symmetry with zero surface shear; (3) normal traction with constant amplitude over a cap of the cavity; (4) normal traction over a zone of the cavity; (5) concentrated load at one pole with zero surface shear; (6) impulsive concentrated load with zero surface shear; (7) concentrated load over a circle on the cavity; (8) uniform tractions with zero surface shear; (9) uniform pulsating load with zero surface shear; (10) blast loading with zero surface shear. For case 10, computations for radial displacement u and radial and tangential stress components were carried out with the aid of a digital computer. Results are presented in nondimensional graphic form. An interesting result is that the radial stress in the neighborhood of the spherical cavity immediately after the blast is tensile. Reviewer believes paper of interest both in theory and in application. A. P. Boresi, USA

396. Solodovmikov, R. V., Transverse impact on an infinite stretched bar (in Russian), *Trudi Khar'kovsk. inzh.-stroit. in-ta.* no. 4, 263–268, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6196.

The small elastic oscillations of the preliminarily stretched homogeneous bar are described by the linear differential equation

$$\frac{\partial^2 v}{\partial t^2} = a^2 \left(\frac{\partial^2 y}{\partial x^2}\right) - b^2 \left(\frac{\partial^4 v}{\partial x^4}\right)$$

where a and b are constants, y deflection, x coordinates, t time.

The starting and boundary conditions correspond to the transverse impact of the load of the end mass with the given velocity of the quiescent bar. N. F. Lebedev, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

397. Ringleb, F. O., Motion and stress of an elastic cable due to impact, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-10, 9 pp.

Relation between impact stress and impact velocity in general case of an oblique impact at a cable has been determined. Relation includes as special cases Saint-Venant's formula for the longitudinal, and author's formula, given in 1948, for the perpendicular impact stress. Using a slight approximation, general formula has been represented by a graph from which impact stress can be determined for a given impact velocity, a given impact angle, and any practical values of the cable material constants and its initial stress. It has been verified that the impact energy and the kinetic and strain energy of the cable are correctly balanced because of the oblique impact relation. Measured impact stresses are compared with theory in case of perpendicular impact for three different cable diameters.

From author's summary by W. L. Esmeijer, Holland

398. Willis, J. M. N., Chisman, S. W., and Bullen, N. I., Measurement and suppression of tension waves in arresting gear rope systems, *Aero. Res. Counc. Lond. Rep. Mem.* 2981, 26 pp., 1957.

Experiments were carried out in order to measure the effect of the tension waves which are induced in an arresting gear rope system after engagement, and to try out means of suppressing these waves with a view to application to projected arresting gears suitable for entry speeds of up to 120 and 150 knots.

Rope tensions were recorded for a series of tests covering a range of entry speeds up to 117 knots with a test vehicle weight of 5,400 lb and up to 151 knots at a weight of 2,450 lb. It is shown that the amplitude of the tension waves becomes relatively greater with increase of entry speed and reaches very serious proportions at the maximum speeds obtained.

The use of resilient rope anchorages has resulted in the suppression of the tension waves to a large extent, reductions in peak tensions of up to 30% under some conditions having been achieved.

From authors' summary

399. Sato, Y., Analysis of dispersed surface waves by means of Fourier transform II. Synthesis of the movement near the origin, *Bull. Earthq. Res. Inst., Tokyo Univ.* **34,** 1, 9–18, Mar. 1956.

In a previous paper [AMR **9,** Rev. 71] author showed how the spectrum of the movement observed at distant places and the dispersive property of the medium through which surface waves were propagated could be obtained numerically. In this paper the formula for obtaining the movement at any point is deduced using the data of the spectrum at some other point and the dispersive formula. The formula is then modified to calculate the law of propagation of surface waves.

The analysis cannot be said to be satisfactory unless it is explained why the curve obtained corresponding to the origin shows "fairly slow oscillation" and is not similiar to the motion of *P*- and *S*-phases. A. M. Sengupta, India

400. Allen, J. E., Impact measurements on a large model of a representative landplane fuselage on water, *Aero. Res. Counc. Lond. curr. Pap.* 283, 19 pp. + 49 figs., 1956.

An experimental investigation has been made into (1) splash-up, (2) impact pressures, and (3) impact forces occurring during controlled alightings on smooth water of a representative landplane fuselage of elliptical cross section in the Hull Launching Tank.

The width of the actual wetted surface of the cylinder was found to be $\sqrt{2}$ times the width which would be wetted for immer-

sion to the same draught without splash-up. Pressure distributions are presented in the form of data for several landings over a range of initial attitudes and at flight-path angles down to 1.5°.

The acceleration results are of limited usefulness due to imperfections in the apparatus.

Photographs are included of the external spray formation.

Results are not generally applicable to design cases for ditching until a rational theory of impact of fuselage shapes is made available. From author's summary

401. Potter, D. S., and Murphy, S. R., On wave propagation in a random inhomogeneous medium, *J. acoust. Soc. Amer.* **29,** 2, 197–198, Feb. 1957.

Elasticity Theory

(See also Revs. 395, 416, 440, 441, 466, 477, 478, 490, 495, 500, 552, 589, 604, 668, 683)

402. Barta, J., On the basic assumptions of the theory of Saint Venant (in French), *Acta Techn. Hung. Budapest* **17,** 1/2, 165–169, 1957.

It is known on the basis of the mathematical theory of elasticity that the Saint Venant theory of the bar utilizes the following assumption: $\sigma_x = \sigma_y = \tau_{xy} = 0$. In this paper it is proved that this assumption can be substituted by minimizing the strain energy. The theorem of existence, the theorem of superposition, and the theorem of unicity for these minimizing procedures are proved. From author's summary

403. Taukach, A. V., Generalization of certain regularities in the strength of materials (in Russian), *Trudi Vologod. moloch. in-ta* no. 13, 315–331, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5462.

Author asserts that "the method of generalizing various phenomena contains rich possibilities for the profound investigation of phenomena and processes," after which he "generalizes" various elementary formulas for the strength of materials.

The "investigation of phenomena and processes" is not advanced by this means. Yu. N. Rabotnov, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

404. Stadelmaier, H. H., Stress field of a force acting upon an elastic anisotropic half plane (in German), ZAMP **8,** 4, 285–290, July 1957.

The stress distribution obtained by solving the two-dimensional problem in an anisotropic medium, with boundary conditions of a concentrated tangential load acting on the boundary of a semi-infinite plate, is purely radial. The solution is given in closed form and is combined with the solution for a concentrated normal load to solve the problem of an inclined force acting on the boundary. [See AMR **10,** Rev. 1027.]

From author's summary by C. B. Biezeno, Holland

405. Kline, L. V., Stress concentration in Plexiglas as a function of loading rate, *J. aero. Sci.* **24,** 7, 551–552, July 1957.

A study is made of stress-concentration effects as functions of loading rate. Polymethyl methacrylate is chosen as the working medium. The loading conditions used are uniform crosshead velocities ranging from 0.02 in. per min to approximately 6600 in. per min. It is shown that failure to recognize the dependence of the stress concentration on the loading rate may result in serious underdesign. From author's summary

406. Saito, H., Stress in a plate containing infinite parallel rows of holes, *ZAMM* **37,** 3/4, 111–115, Mar./Apr. 1957.

Paper deals with distribution of stress in a perforated plate having evenly spaced rows of circular holes. Results are given for the stresses when the holes are spaced in equal rows and lines and when the ratio of hole radius to hole spacing is 0.10, 0.15, 0.20, 0.25, and 0.27. Tensile loads are considered: (1) parallel to the rows of holes; and (2) at a 45° angle to the rows of holes. The circumferential stress at six equi-angular locations is tabulated. For load parallel to the rows of holes the maximum stress concentration factor is 3.00; while for load at 45°, the maximum value is 3.29 when the hole radius is one quarter the hole spacing. The method of solution involves the use of an infinite series of stress functions in polar coordinates. A perturbation method is used to determine the coefficients. S. Levy, USA

407. Matting, A., Development of airplane parts without stress concentrations, *Jahrbuch Wissenschaft. Gesellsch. Luftfahrt* 206–213, 1956.

Second prize winner in German technical essay contest, author describes three disconnected technical developments made at the Technical University of Hannover which aid in reducing stress concentrations.

The use of organic adhesives between metal parts to reduce stresses due to welds, rivets, etc., is well known. Author shows how the use of cold setting adhesives can be improved by applying ultrasonic energy to the parts during setting of the adhesives. Ultrasonic energy is believed to cause more uniform polymerization and adhesion. Tests show greater strength and uniformity.

To improve fatigue resistance of joints, author compares glued, welded, glued and rigid welded, and glued and "elastically" welded joints. In the latter, the metal around the weld is partially removed by drilling on one of the metal parts so that the weld is on an "island," as it were, connected only by thin elastic webs to the main member. Author obtains as much as 100% improvement in endurance over glued joints.

Notch sensitivity of high tensile steels can be improved by filling notches with soft austenitic weld metal. This appears to improve fatigue resistance, although only a few test results on a drilled sample are shown. E. G. Chilton, USA

408. Pindera, J., Some remarks on the method of evaluation of stress concentrations in combined notches proposed by W. Moszynski (in Polish), *Rozprawy Inz.* **4,** 2, 289–306, 1956.

In this paper published in 1953, W. Moszyński proposed a formula for the over-all coefficient of shape

$$\alpha_k = \sum_{i=1}^{m} \alpha_k^i - m + 1,$$

in the case of m notches described by shape coefficients α_k^i, and where the stress concentration due to each of them appears in the same cross section. The present author's aim is an experimental verification of W. Moszyński's formula by means of the photoelastic method.

Stretched strips with lateral notches of uniform depth and of plane bottom were used as models, the length of the bottom being different for each model. Strips with round and oval holes located in the axis of the strip were also examined. The comparison with Moszyński's formula shows differences amounting to 12%.

W. Urbanowski, Poland

409. McClure, G. M., Secondary stresses in large-diameter pipelines, *Proc. Amer. Soc. civ. Engrs.* **83,** PL 2 (*J. Pipeline Div.*), Pap. 1280, 12 pp., June 1957.

There are a number of sources of secondary stresses in line pipe during shipment of the pipe and during construction and operation of a line. Predominant secondary stresses are discussed, and some examples of their magnitudes are given. Stresses and localized points are the most significant. To eliminate detrimental stresses of this type, a high test pressure after construction is considered important. From author's summary

410. Tipton, E. W., Mechanical problems involved in short circuits on core-form power-transformer coils, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-46, 9 pp.

Modern power transformers are being subjected to more frequent and to more severe short circuits than they were in years past. Under short circuit the windings are subjected to severe mechanical stresses, but the materials used in the coils cannot be selected for their mechanical properties. An analysis of the forces and of methods of applying the materials available shows how successful coil structures can be fabricated. From author's summary

411. Chattarji, P. P., A note on torsion of circular shafts of variable diameter, *J. appl. Mech.* **24,** 3, 477-478, Sept. 1957.

Stress function is found in the form of polynomials, and possible shapes of shafts are presented. But the reviewer can hardly find its application to practical problems, as occurred with the similar solution previously obtained by Abbassi [AMR **9,** Rev. 3555], since the stresses in shafts are infinite at $r = 0$ or $z = \infty$.

Illustration of the use of the solution would be of more practical interest. H. Okubo, Japan

412. Wittmeyer, H., Approximate formula for the calculation of torsional rigidity of multicellular thin-walled hollow prisms (in German), *ZAMM* **36,** 11/12, 436-443, Nov./Dec. 1956.

Torsional rigidity of thin multicellular tubular sections has been exactly calculated by Föppl and Goodey by solving linear equation systems. An approximate iteration method was given by Barta (1955). Present paper gives an approximate direct solution: Rayleigh's principle is used for finding a result which is a little lower than largest eighvalue of an algebraic eigenvalue problem. Approximation is enough for technical problems, as is proved in two numerical examples in which multiply-connected sections formed by thin squares are solved. Approximate solution is compared with exact result and with Barta's solution.

H. Fernandez Long, Argentina

413. Heldenfels, R. R., and Vosteen, L. F., Approximate analysis of effects of large deflections and initial twist on torsional stiffness of a cantilever plate subjected to thermal stresses, *NACA TN* 4067, 22 pp. + 16 figs., Aug. 1957.

Initial twist of a uniformly thick rectangular cantilever plate and applied moments can significantly affect changes in stiffness produced by nonuniform heating. Von Karman's large-deflection equations, modified to include initial twist and nonuniform temperature distributions, are solved approximately, using a variational principle of Reissner [AMR **7,** Rev. 1042] and simple modal functions for torsional deflection. Effective stiffness decreases with increasing thermal stress, reaches zero at buckling temperature difference, and beyond buckling temperature increases as plate twists. Change in stiffness of a plate with initial twist reaches a non-zero minimum before buckling temperature difference is reached; if twist is sufficiently large, stiffness actually increases with heating. Twist and frequency calculated by this large-deflection analysis show much better agreement with experiment than small-deflection theory previously applied [*NACA RM* L55E20c, 1955]. E. T. Welmers, USA

414. Filimonov, V. G., Construction of curves of true stress from tests of porous metal-ceramic specimens (in Russian), *Zavod. Lab.* **21,** 1, 82-84, 1955; *Ref.Zh. Mekh.* 1956, Rev. 5602.

In order to determine the true stresses during compression in a metal-ceramic porous material on the basis of the author's experiments, the following formula is recommended

$$\sigma = \frac{P}{F}\,\frac{1}{1 + 1.95\,\varepsilon^2}$$

In which P is the compressing force, F is the original area of the cross section, and ε is the axial deformation.

Courtesy Referativnyi Zhurnal N. V. Dokukina, USSR
Translation, courtesy Ministry of Supply, England

415. Nekrasov, S. S., Possibility of using the contact problem of the theory of elasticity for determining the distribution character of the load on the front edge of a cutting tool (in Russian), *Nauch. zap. kafedry tekhn. distsiplin Mosk. finans. in-ta,* Moscow, 50-53, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5344.

A solution of the problem whether or not it is possible to apply I. Ya. Shtaerman's solution of the plane contact problem of the theory of elasticity for a die with rounded edges to the calculation of the pressure over the front edge of the cutting tool. For this purpose it is necessary to estimate the maximum error occuring when the action of one half of the semi-space on the other is disregarded. Author obtains this estimate by replacing the true curve of pressures under the die by a simplified trapezoidal one, which joins by a straight line the points having ordinates of σ_{min} σ_{max}. The ordinates of this curve deliberately exceed the ordinates of the true curve. By this means author obtains an estimate of the error not exceeding 12.5% (at $\mu = 0.25$), and concludes from this that, in practice, I. Ya. Shtaerman's solution can be used.

Courtesy Referativnyi Zhurnal N. A. Rostovtsev, USSR
Translation, courtesy Ministry of Supply, England

Experimental Stress Analysis

(See also Revs. 417, 484)

416. Godfrey, D. E. R., Two-dimensional stress and inertia combinations, *J. roy. aero. Soc.* **61,** 557, 353-354, May 1957.

Author shows again the well-known similarity between the components of plane stress and the moments and products of inertia. By using complex notation, an Argand diagram, analogous to Mohr's circle, can be drawn. Reviewer believes that Mohr's circle is simpler to use correctly than author's method, if Mohr's rule for the sign of the shear stresses, neglected by most authors, is properly used. An application to photoelastic analysis is also made.

N. C. Costakos, USA

417. Ordahl, D. D., and Williams, M. L., Preliminary photoelastic design data for stresses in rocket grains, *Jet Propulsion* **27,** 6, 657-662, June 1957.

The charts given in this paper will be appreciated by designers of rocket propellant grains. Authors have conducted a long series of tests; however, after the results are plotted, the conclusions seem to be based on small experimental evidence. This is due to the large number of parameters influencing the results. Authors are well aware of this fact. This kind of work should therefore be extended and more experimental data accumulated to give more weight to the conclusions.

Authors claim that for most "engineering purposes" there is sufficient similarity between the stress pattern produced by internal pressure on unsupported perforated grains and the stress pattern produced by differential thermal expansion in case-bonded grains of the same geometry, to warrant the use in the design of case-bonded grains of charts computed using unsupported grain stress patterns. The reviewer agrees with this contention. Authors claim also that for "engineering purposes" the same results can be obtained by imposing an external pressure upon the external boundary of a grain model as by imposing an internal pressure upon the internal contour of a model of a grain of the same geometry. Reviewer likes to point out that this fact is not an approximation used for engineering purposes but that it can be proved rigorously. In both cases the maximum shear distribution is the same.

A. J. Durelli, USA

418. Leven, M. M., Three-dimensional photoelasticity, *Prod. Engng.* **28,** 7, 135–140, July 1957.

419. Rehling, K., Elimination of temperature effects in strain measurements (in German), *ZVDI* **99,** 11, 461–466, Apr. 1957.

420. Tanaka, S., Takuya, N., and Yamada, T., X-ray strain measurements with a twin-counter, *Technol. Rep. Osaka Univ.* **5,** 245–250, Oct. 1955.

"A twin-counter method" was developed for relative measurements of the lattice constants. A special twin-type x-ray counter was constructed, and, using it and authors' experimental conditions, the errors in the determination of the lattice parameter are of the order of 3×10^{-5} kX. From authors' summary

421. Hawkes, G. A., The measurement of surface residual stress by x-rays, *Brit. J. appl. Phys.* **8,** 6, 229–232, June 1957.

A multi-exposure, x-ray, back-reflection technique, with graphical solution for the evaluation of the level of residual macro-stress in any particular surface direction in a polycrystalline material, is described. This technique has, in particular, been applied to the stress analysis of aluminum alloys and high-tensile steel components and specimens. From author's summary

Rods, Beams, Cables, Machine Elements

(See also Revs. 387, 388, 389, 390, 391, 397, 398, 402, 411, 450, 467, 471, 476, 477)

422. Zyczkowski, M., The problem of the most suitable form for axially compressed bars (in Polish), *Rozprawy Inz.* **4,** 4, 441–456, 1956.

The relation between the form of an axially compressed bar and its weight is discussed. The discussion is reduced to the case where the radius of the cross section changes linearly with its length. The optimal taper securing minimum material is determined for a constant critical force. In the case of elastic buckling the economy obtained is 10.34%. In the elastic-plastic region it oscillates between 0 and 10.34% in relation to prismatic bars.

M. Sokolowski, Poland

423. Shaffer, B. W., and House, R. N., Jr., The significance of zero shear stress in the pure bending of a wide curved bar, *J. aero. Sci.* **24,** 4, 307–308, Apr. 1957.

A general solution is obtained for the displacements and strains within a wide curved bar made of an incompressible, perfectly plastic material subjected to zero shear stress. The solution, which is equally applicable for the elastic and plastic regions of the bar, shows that plane sections remain plane throughout the loading program. From authors' summary

424. Malinin, N. V., Nonmoment state of a rotating slightly bent rod (in Russian), Racchety na prochnost elementov mashinostroit. konstruktsii, Moscow, 1955; 29–34, *Ref. Zh. Mekh.* 1956, Rev. 5413.

Author finds the equation of the axis and the formula for the setting angle of a slightly bent rod of variable cross section, loaded with a load distributed perpendicularly to its axis and rotating about a straight line lying in its plane, under the condition of the absence of bending moments and transverse forces in the sections of the rod.

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

425. Khatiashvili, J. M., The elastic equilibrium of a compound cylindrical bar with a loaded lateral surface in the light of the various Poisson coefficients (in Russian), *Soobshch. Akad. Nauk Gruz. SSR* **16,** 1, 19–25, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6139.

An examination is carried out of the generalization of Mitchell's problem, to cover the case of the deformation of a cylindrical body, made up of a series of parallel bars, not touching each other, surrounded by a cylindrical surface, parallel to the axes of the bars. The spaces between the cylindrical surface and the bars is filled with an elastic medium. The elasticity of the bars and of the surrounding medium is taken to be dissimilar.

The lateral surface is assumed to be loaded with distributed stresses, which are constants along the generatrix.

The problem is solved for the tensional stresses. Author makes use of preliminary structural solutions of auxiliary plane studies, corresponding to the given movement on the borders of the cross sections of the bars and surrounding medium (in the absence of external forces), and introduces a set of auxiliary tensional functions, for which he obtains differential equations and boundary conditions. From the conditions of solvability of these problems, four unknown constants are determined, which take part in the expression for tension through auxilliary functions. G. Yu. Dzhanelidze, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

426. Akivenson, M. Yu., Theory of the elastic line when there is spatial deformation of a broken bar (in Russian), *Nauch. zap. Odessk. politekh. in-ta* **5,** 2, 35–39, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6242.

A formula is derived to determine the perpendicular to the axial plane-change of position of any point of the axis of the flatly broken bar, while considering the bending and torsion of the elements concerned. The load is perpendicular to the plane of the axis line. A numerical example is given.

Courtesy Referativnyi Zhurnal A. A. Gorin, USSR
Translation, courtesy Ministry of Supply, England

427. Tolokonnikov, L. A., Finite deformations in pure bending of a rectangular bar (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **22,** 188–192, 1955.

First the author establishes compatibility equation relating the tangential strain to the radial strain. Next, from the equilibrium of an element in the tangential direction, a differential equation is written which involves the tangential strain, tangential and radial stresses, and the strain normal to the plane of bending. In the derivation of this equation, the size of the element after deformation is used. The necessary boundary conditions are: zero radial stresses at the two boundaries, zero tangential stress at the neutral surface, and the integral of the tangential stresses multiplied by the differential area and lever arm equals the applied bending moment.

For a specific application, author considers a strip of incompressible material, and finds the coefficient which, multiplied by the bending moment as in strength of materials, but modified, yields the actual bending moment. This coefficient is calculated and tabulated for different ratios of thickness to radius of curvature of the incompressible strip.

There is a typographical error in Eq. 1.6 and perhaps wrong sign in Eq. 2.13, and one dimension in Fig. 1 seems to be incorrect. Specific reference to literature and more steps in some derivations would have been desirable. The range of the radius of curvature seems open to question, and the fact that the coefficient mentioned before has a minimum is intriguing—since a small error in calculations can change the picture.

S. Sergev, USA

428. Amenzade, Yu. A., Problem of bending hollow prismatic rods (in Russian), *Trudi Azerb. n.-i in-ta po dobyche nefti* no. 1, 54–60, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5346.

Examination of the bending of a homogeneous isotropic hollow prismatic beam, the section of which has the form of a circle

weakened by a symmetrically disposed square cut-out. The beam is fixed at one end, and the force is applied along the large axis of the square to the free end.

The problem, which reduces to the basic problem of the potential theory for the region of the section at a certain given function on the contour, is solved approximately by the known method, using the theory of functions of a complex variable. The region of the section is approximately reflected on the circular ring (the expression for the reflecting function being taken in the form used by D. I. Sherman [*Izv. Akad. Nauk SSSR. Otd. tekh. Nauk* no. 7, 1951]); the required holomorphous function in the ring is replaced by a segment of the Lorand series and its coefficients are determined. The solution found is used for determining the shear stresses. A. I. Kalandiya, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

429. Khokhlov, K. K., Calculation of the upper structure of the track of wood-transporting narrow-gauge railroads by the method of a solid distributing elastic foundation (in Russian), *Tekhn. inform. Mosk. lesotekhn. in-ta* no. 2, 12–31, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5438.

An explanation of the calculation of the upper structure of the track of narrow-gauge railways as girders on a solid elastic foundation takes into consideration the mutual influences of settling, so that the calculation becomes the solution of the bending equation

$$EI\frac{d^4y}{dx^4} - V\frac{d^2y}{dx^2} + uy = 0$$

in which V is the factor taking into account the mutual influence of settling, EI is the rigidity of the girder, and u is the bed coefficient.

Tables are given of test and calculated values of the pressure of the rails on the sleepers, which are in good agreement with practice. A. F. Rozhnyatovskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

430. Banerjee, S. P., Beams of finite length on elastic foundations—a new approach to solution, *J. Instn. Engrs., India* **37,** 3, part 1, 139–158, Nov. 1956.

431. Szelagowski, F., One-directional tension of a circular ring (in Polish), *Rozprawy Inz.* **4,** 4, 431–439, 1956.

A circular ring with a rigid circular inclusion subjected to simple tension by forces of intensity p acting on the outer periphery, and a circular ring subjected to simple tension by forces of intensity p on the outer periphery, and forces of intensity q on the inner periphery, are discussed.

Expressions for stresses are obtained in a closed form. The solution is obtained using functions of the complex variable.

J. Mossakowski, Poland

Plates, Disks, Shells, Membranes

(See also Revs. 392, 394, 406, 413, 451, 452, 453, 454, 455, 461, 490)

432. Pearson, C. E., On the finite strip problem, *Quart. appl. Math.* **15,** 2, 203–208, July 1957.

The singular integral equation $\int_a^b [P(x-t)\ln|x-t| + Q(x-t)]f(t)dt = g(x)$ $a < x < b$, where P, Q, g, are prescribed well-behaved functions, is usually solved approximately by Wiener-Hopf method when the interval (a, b) is long; by the use of Carleman's formula for $\int_{-1}^{1} f(t)\ln|x-t|\,dt = g(x)$ when the interval is so short that only the zeroth-order term of $P(x-t)$ is sufficient; and by infinite series expansion or numerical technique when the interval is of moderate length. Author gives an exact solution for the moderate length of the interval, when P and Q are of nth-order, by the use of Cauchy's integral theorem and application of Laplace transform. As illustrations, the cases when $P = 1$, $Q = 0$ and $P = 1 + kx$, $Q = 0$ are worked out. Several useful integrals continually occurring in the method are also collected. Evidently the method becomes tedious when the order of the polynomials P and Q increases. B. R. Seth, India

433. Koiter, W. T., and Alblas, J. B., On the bending of cantilever rectangular plates, IV, *Proc. k. Ned. Akad. Wet. (B)* **60,** 3, 173–181, 1957.

Authors consider the bending of a 2-unit wide semiinfinite cantilever plate subject to a constant pressure distribution. In parts I and II [AMR **8,** Revs. 611, 612] they investigated the singular behavior of moment and shear force in the corners, in part III [AMR **8,** Rev. 3365] they solved the problem of the semiinfinite strip by establishing first a Fourier integral expression for the deflection $u(x,y)$, and then converting this into a biharmonic eigenfunction expansion. (An intermediate step is finding the expression, at $x = 0$, of the shear force and determining the Fourier expansion coefficients of the root moment, in terms of deflection and slope.)

The following is demonstrated. The moment is largest at $(x,y) = (0,0)$. There is a rapid decay of end effects. The Carrier-Shaw method [*Proc. Symp. appl. Math.* **3,** p. 125, 1950] is unsuitable for determining the biharmonic eigenfunction expansion coefficients, but the residue method, using the Fourier integral formulation as a take-off, is suitable. The biharmonic eigenfunction expansion is unsuitable for determining results near the corners $(x,y) = (0, \pm 1)$ of the strip. [In these places one should work directly with the Fourier integral expressions.]

Besides giving the solution of an important stress problem, authors' four papers also contain much valuable information on the handling of Mellin and Fourier transforms.

G. Herrmann, USA

434. Thrun, Z., Thermal deformations and stresses in thin rectangular plates of variable thickness (in Polish), *Rozprawy Inz.* **4,** 4, 523–541, 1956.

A differential equation for a plate of variable thickness subjected to temperature difference between the upper and lower face is derived. Steady temperature fields are considered. Some very simple cases concerning rectangular, circular, and annular plates with axially symmetrical temperature distribution are discussed in detail. The paper contains numerical examples and presents approximate methods. J. Mossakowski, Poland

435. Aronson, A. Ya., Evaluation of the sector of a slab of variable thickness (in Russian), Gidroturbostroenie, no. 1, Moscow-Leningrad, Mashgiz, 1955, 163–174; *Ref. Zh. Mekh.* 1956, Rev. 6150.

The problem is investigated of the bending of a slab to the shape of a circular sector, of which the cylindrical rigidity changes along its radius r according to the principle

$$D = D_0(1 - k_1\rho^2) \quad [\rho = (r/R)]$$

where R is outer radius of the slab, D_0 rigidity at the center of the slab, $k_1 < 1$ = constant.

Using the solution of the problem on the asymmetrical bending of a round slab of the given rigidity as put forward by E. S. Umanski [*Sb. tr. In-ta stroit mekhaniki Akad. Nauk SSSR* no. 17, 1952]; author brings together the solution of the original differential equa-

tion of the fourth order and the solution of the heterogeneous differential equation of the second order with irregular derivatives. The integration of this equation, in the case of any given surface transverse loading and when heterogeneous boundary conditions affect the rectilinear edges (assigned owing to the distribution of deflection and of bending moment), is accomplished with the help of J. A. Grinberg's method ["Selected problems on the mathematical theory of electrical and magnetic phenomena," Moscow-Leningrad, Izd-vo Akad. Nauk SSSR, 1948].

This includes the expansion of the solution into a series arranged according to certain natural functions of the equations, corresponding to the divided variables; here, at the curvilinear edges, the boundary conditions may have any value, provided the principal vector and the principal stress moment, acting on the slab, are equal to zero.

As an example, an examination is made, combined with the study on the bending of the flange of the blade of a hydroturbine, of the bending along the perimeter of a semicircular slab having a thickness corresponding to the given rigidity, subjected to the influence of a bending moment, evenly distributed along the diameter. Numerical calculations are not given.

It is noted (by the abstractor) that, as the function of the deflection analyzed satisfies heterogeneous border conditions, while the individual functions investigated in this study are homogeneous, then, generally speaking, the series in which the solutions are presented converge slowly; and without an improvement in convergence, the solutions may prove unsuitable for calculating the bending moment and transverse forces. In the case in point unsuitability is also indicated in the linear relation (24) between the hypergeometrical functions from $k_1\rho^2$ and $1 - k_1\rho^2$ (parameter $a + b - c + 1 = 0$); the apparently changed relation should contain logarithmic terms. A. D. Kovalenko, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

436. Dyrbye, C., Circular cast-iron plates, *Acta Polyt., Civ. Engng. Bldg. Const. Ser.* **3,** 7, 12 pp., 1956.

Caused by the curved stress-strain diagram of cast-iron, neither the theory of elasticity nor the plastic theory can be used for the calculation of the rupture load. For a circular plate supported on three points and loaded in the center, author shows that the two theories give differences of 75% in the calculated rupture load. Tests on plates corresponding to two castings gave rupture loads which were 20 to 27% above the theory of elasticity, and 29 to 32% below the plastic theory, i.e., nearly midway between the values calculated according to these two theories. For calculating with the plastic theory, it is necessary to employ a suitable correction factor which is below 1. F. Wever, Germany

437. Fleishman, N. P., Bending of an infinite plate having a reinforced circular hole (in Russian), *Nauk. zapis. Lvivsk. un-tu* **29,** 6 (1), 105–111, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5342.

Examination of the problem of the bending of thin infinite isotropic plate, in a circular hole of which is soldered a thin elastic ring of a different material.

The plate is bent by the given forces to infinity. Along the axial line of the reinforcing ring act external transverse stresses and bending moments, the main vector and the main moment of which are equal to zero. The problem is solved by the method of functions of a complex variable.

An example is given of the selection of the reinforcing ring of rectangular section in conditions of complete removal of concentration of stresses in the plate.

An examination is made of an infinite rectangular isotropic plate with reinforced circular hole, bent by moments uniformly distributed on two opposite sides. A. F. Rozhnyatovskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

438. Szelagowski, F., An infinite plate having a circular hole and subjected to tension by concentrated forces (in Polish), *Rozprawy Inz.* **4,** 4, 505–513, 1956.

Using a function of the complex variable, a closed expression is obtained for stresses in an infinite plate, weakened by a circular hole and subjected to tension by two opposite concentrated forces passing through the center of the hole. Results are discussed and compared with the stresses in a plate without a hole.

J. Mossakowski, Poland

439. Szelagowski, F., An infinite plate having a rigid circular inclusion and subjected to tension by concentrated forces (in Polish), *Rozprawy Inz.* **4,** 4, 515–521, 1956.

An infinite plate having a rigid circular inclusion is subjected to tension by two opposite concentrated forces passing through the center of the circle.

Expressions in closed forms are obtained for stresses in the plate, using functions of complex variable.

J. Mossakowski, Poland

440. Buchwald, V. T., A mixed boundary-value problem in the elementary theory of elastic plates, *Quart. J. Mech. appl. Math.* **10,** 2, 183–190, May 1957.

Method of the functions of complex variable, used by Muskhelishvili in solution of plane problems for bodies occupying semi-infinite regions, is adapted in a modified form to solutions of bending of semi-infinite plates with mixed boundary conditions. The mixed boundary conditions are specified as follows: a plate is clamped segmentwise along finite boundary and simply supported otherwise. The results show that the stresses are infinite at the points of discontinuities of the boundary conditions. However, the order of magnitude of these stresses is smaller than for concentrated loads.

R. M. Evan-Iwanoski, USA

441. Salles, F., and Thiry, M. R., Contribution to the approximate mathematical determination of constraints in plates (in French), *Publ. sci. tech. Min. Air, France* no. 321, 159 pp., 1956.

The plane stress problem of two-dimensional elasticity is treated by two approximate techniques in this monograph. In the first approach, termed the "method of single strips," a body having a rectangular contour is considered to be divided into a number of narrow strips oriented in the direction of the longer of the two dimensions. The only external loads acting on the body are normal forces applied to either of the shorter sides of the body. It is arbitrarily assumed that the components of displacement in the plane of the plate and normal to the direction of loading are zero, and further it is assumed that the normal stresses perpendicular to the direction of loading are also zero. A system of linear algebraic equations is then formulated for the shearing stresses acting between adjacent strips and the direction of loading. Several boundary-value problems involving rectangular bodies having one end completely restrained against displacements and the other end loaded in either of several fashions are presented. In particular, the case of two concentrated forces, one acting at each extremity of a short side and oriented in the direction of the longer dimension, with the other short side being completely restrained, is discussed in detail. The body is arbitrarily divided into four longitudinal strips and the calculated stresses differ from those found experimentally by electric strain-gage techniques by at most 15%. No attempt is made to improve accuracy by considering a larger number of strips. The case of a multiply-connected body subject to a state of plane stress is also discussed. In the last section dealing with this method of approximation the problem of a thin-walled box beam having a rectangular cross section and subject to various loads is treated in detail.

The second approach, termed the "method of double strips," divides the body of rectangular contour into a number of smaller rectangular elements, formed by the intersections of orthogonal cutting

planes. In each of the two orthogonal directions the treatment is now the same as the first approach. The normal stresses constituting the bi-axial field are thus considered in this approach, but the differential equations of equilibrium are not necessarily satisfied. An example is presented for a rectangular body loaded by shear forces at discrete points along one side.

The results presented are readily applicable only to bodies having rectangular contours. Unfortunately, authors present no comparisons of accuracy with existing approximate methods, such as those due to Southwell. W. A. Nash, USA

442. Klein, B., Further remarks on the collapse pressures of uniformly loaded spherical shells, *J. aero. Sci.* **24,** 4, p. 309, Apr. 1957.

443. Hodge, P. G., Jr., The influence of blast characteristics on the final deformation of circular cylindrical shells, *J. appl. Mech.* **23,** 4, 617–624, Dec. 1956.

Shells of finite length with rigid built-in ends deform symmetrically. Material is rigid-plastic and non-workhardening. Briefly applied pressure is uniform over cylindrical surface and is assumed to vary in different ways with time. Practicable studies require the applied load of the same order of magnitude as the static "collapse" load at which deformations become abruptly large. Various analytic approximations are tried for the shell theory used but are rejected in favor of graphical-numerical methods. Author states that "the relation between the displacement so computed and the actual behavior of real shells is by no means clear." No experimental check is available.

K. H. Swainger, England

444. Alfutov, N. A., and Razumeev, V. F., Dynamic stability of a conical shell supported at one end, loaded by axially symmetrical pressure (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekhn. Nauk* 10, 161–165, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5396.

An investigation of the parametric oscillations of a circular conical shell supported at one end and loaded with uniform transverse pressure.

It is assumed that with this attachment the mean surface is deformed without elongation or shearing. From this the kinetic energy of the system, the internal potential energy, and the potential of the external forces are determined. The Lagrange equation which describes the dynamic process, after certain transformations, is reduced to a familiar differential equation of the Mathieu type. The boundaries of the first and second critical regions of dynamic instability are indicated. For envelopes having a conicity of $2\alpha = 12°$, $2\alpha = 18°$ at a pressure of $P \neq 0$ the theoretical results are compared with those of the experiment. The extent of applicability of the solution is not explained. In view of the assumption of the nonelongation of the mean surface in the general case, i.e. at $P \neq 0$, the solution is correct only for long shells.

Courtesy Referativnyi Zhurnal A. V. Sachenkov, USSR
Translation, courtesy Ministry of Supply, England

445. Wildhack, W. A., Dressler, R. F., and Lloyd, E. C., Investigations of the properties of corrugated diaphragms, *Trans. ASME* **79,** 1, 65–82, Jan. 1957.

The pressure-deflection characteristics of corrugated diaphragms are correlated by methods of dimensional analysis. Experimental results for various sizes, materials, thicknesses, and shapes of diaphragms indicate that the performance for diaphragms of any given shape may be computed from a dimensionless formula derived from experimental data on other diaphragms of that shape. Linear shell equations are derived for combined bending and stretching effects with lateral loading terms for rotationally symmetrical shells in appropriate independent and dependent variations suitable for complicated meridial shapes, and with boundary conditions associated with practical diaphragm applications. The method used for solving this system of equations on an electronic digital computer is described and numerical solutions are presented for a specific diaphragm subjected to uniform pressure loading. Suggestions are presented for future research, both theoretical and experimental, on diaphragm properties and performance.

From authors' summary

446. Mansfield, E. H., The stress distribution in panels bounded by constant-stress edge members, *Aero. Res. Counc. Lond. Rep. Mem.* 2965, 11 pp. + 4 figs., 1957.

The stress distributions in long panels bounded by constant-stress edge members are derived from equations of elasticity and expressed in closed form. Influence of closely spaced stringers and ribs on the peak shear stresses is shown. Contours of stress in the panel are given. T. H. Lin, USA

447. Roth, W., Membrane stresses in a helically twisted tube (in German), *ZAMM* **37,** 3/4, 115–128, Mar./Apr. 1957.

For a helically twisted spiral tube of circular cross section, the state of stress is derived when the tube is under pressure and acted upon by forces and moments at the tube ends. The membrane theory leads to equations that can be integrated exactly.

From author's summary by M. Botman, Canada

Buckling Problems

(See also Rev. 463)

448. Filippov, A. P., The load-carrying capacity of compressed-bent columns with residual stresses (in Russian), *Tr. Kharkovsk. politekhn. in-ta* **5,** 103–120, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5377.

A determination of the limiting load-carrying capacity of a column of rectangular section according to given elasticity and eccentricity, and also the maximum permissible eccentricity. The results of tests with eccentric compression on specimens with and without initial stresses are given.

Courtesy Referativnyi Zhurnal A. F. Rozhnyatovskii, USSR
Translation, courtesy Ministry of Supply, England

449. Pinadzhyan, V. V., Problem of the limiting state of short eccentrically compressed columns of H-shaped section in the case of double-axis eccentricity of the force application (in Russian), *Dokladi Akad. Nauk Arm. SSR* **21,** 2, 57–62, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5375.

An investigation is made of the load-carrying capacity of longitudinally-compressed columns of H-section when the point of application of force is eccentric, in accordance with the theory of thin-walled rods.

The value of the critical load at given eccentricities e_x and e_y is determined according to the formula

$$P = \phi F \sigma_T$$

where F is the cross-sectional area of the column, σ_T is the yield point, and ϕ is a coefficient, the value of which is taken from the graph.

The results of tests of bi-axial eccentric compression of seven H-section columns are given which determined the values of the critical loads (in obtaining which the simultaneous bending and torsion of the racks was observed at the place of application of the load).

A table is given of the values ϕ and ϕ_0 (coefficient of reduction of the yield point in the case of eccentric compression of the column). A. F. Rozhnyatovskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

450. Akivenson, M. Yu., Three-dimensional buckling of a broken rod (in Russian), *Nauch. zap. Odessk. politekhn. in-ta* **5,** 2, 81–85, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5448.

The problem of the stability of a plane form of bending of *L*- and *U*-shaped sections is solved. N. K. Snitko, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

451. Klein, B., Shear buckling of simply supported rectangular plates tapered in thickness, *J. Franklin Inst.* **263,** 6, 537–541, June 1957.

Design curves are presented for determining the elastic buckling loads of a class of simply supported rectangular plates linearly tapered in thickness in one direction and loaded in pure shear. The problem is solved by a simple straight-forward numerical method involving a very small matrix. From author's summary

452. Pezzoli, G., Circular plate in pressure buckling (in Italian), *G. Gen. civ.* **95,** 3, 208–213, Mar. 1957.

Assuming the usual hypotheses of thin plate theory, author treats the buckling problem of circular plate submitted simultaneously to uniformly distributed compressive forces around the edge of the plate N and the normal uniformly distributed loads q or concentrated load P at the center of the plate, solving directly the governed differential equation. Two cases are discussed: (a) plate with clamped edge, and (b) simple supported plate. The solution of the known differential equation is given as linear combination of Bessel functions of the first and second kind of the first order. It is shown that in both cases the critical values of the compressive forces have the same values as in the case of pure buckling, i.e., when $q = 0$ or $P = 0$ [Timoshenko, "Theory of elastic stability," McGraw-Hill, 1936, p. 367]. The expressions for the bending moments, for the angle between the axis of revolution of the deflection surface and any normal to the plate's surface element, and for the displacements are found.

Further, author treats the case when the acting forces are tensile forces instead of compressive. In this case, the general solution has the form of a Bessel modified equation with the Bessel modified functions of the first and second kind of the first order. While these functions are not of the oscillating type, author deduces that a critical phenomenon does not exist, but that the expressions for the deflection surfaces are determined.

D. Raskovic, Yugoslavia

453. Shuleshko, P., Buckling of rectangular plates with two unsupported edges, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-46, 4 pp.

Using a method (long) presented in a previous paper [*J. appl. Mech.* **23,** 3, 359–363, Sept. 1956], numerical values of buckling loads are obtained for rectangular plates compressed in two perpendicular directions with two edges simply supported and two edges unsupported. M. V. Barton, USA

454. Reiss, E. L., Greenberg, H. J., and Keller, H. B., Nonlinear deflections of shallow spherical shells, *J. aero. Sci.* **24,** 7, 533–543, July 1957.

Paper presents the results of extensive calculations made on the AEC UNIVAC at New York University for power-series solutions of nonlinear equations given by W. Z. Chien [*Quart. appl. Math.* **2,** 2, 120–135, July 1944] and rederived by authors from variational principles. Results apply to axisymmetric deformations of title shells under uniform external pressure, when clamped around circular rims or when parts of complete spheres. Stresses and deflections are displayed on a large number of graphs as functions of two parameters, related to pressure and to shell geometry. Initial buckling pressures, p_{crit}, were predicted from considerations of convergence of numerical procedure. Lower pressures required to maintain buckled shapes were not computed, although a few load-deflection relations were obtained for postbuckled states.

Authors anticipate further numerical study in this region. Predicted critical pressures depend on shell geometry in a manner similar to experimental results of A. Kaplan and Y. C. Fung [AMR **8,** Rev. 2330]; central deflections before buckling agree closely with these experiments for less shallow shells, less closely for flatter shells under higher pressures. L. Maunder, Scotland

455. Hoff, N. J., Buckling of thin cylindrical shell under hoop stresses varying in axial direction, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57-APM-20, 8 pp.

The buckling of a thin circular cylindrical shell simply supported along the perimeter of its end sections is analyzed under hoop compressive stresses varying in the axial direction. The thermal stresses arising from a uniform increase in the temperature of the cylinder are determined. It is found that such thermal stresses are not likely to cause elastic buckling. Simple approximate formulas are developed for buckling stress and thermal stress.

From author's summary by M. Botman, Canada

456. Eimer, C., The stability of elements prestressed by means of hooping (in Polish), *Rozprawy Inz.* **4,** 4, 543–565, 1956.

The stability of circular ring under the action of a compressive force along the periphery due to prestressed hooping is considered. Linear elasticity of material is assumed and the nonlinear theory of thin beams is used. The results show that the undistorted ring is stable at arbitrary values of the compressive force, the buckling of the ring being only effected by external forces involving additional distorsion. D. Niepostyn, Poland

457. Stabilini, L., Buckling, tipping and swelling in steel constructions Parts I, II, (in German), *Schweiz. Arch.* **22,** 11, 363–374, Nov. 1956; **22,** 12, 377–388, Dec. 1956.

This twenty-two page review article touches lightly on a wide variety of problems in structural stability. Relatively few specific results are presented. Reviewer believes the paper's greatest value is to serve as a guide to the literature (146 references).

S. B. Batdorf, USA

Joints and Joining Methods

(See Revs. 407, 490)

Structures

(See also Revs. 446, 456, 457, 467, 480, 486, 497, 683)

Book—458. Williams, C., and Harris, E., Structural design in metals, second edition, New York, The Ronald Press Co., 1957, viii + 655 pp. $8.

The second edition [see also AMR **2,** Rev. 1499] continues to be a sound and well-organized text for a first course in structural design. It is primarily for use at the junior-senior level for a civil engineering curriculum. Reviewer noted no changes of significance in the first ten chapters. The eleventh chapter, on rigid frames, has been slightly expanded to include some examples of building frame design. Specifications have been brought up to date. Reviewer believes that inclusion of "design sheets" as used in older texts would have helped beginning students.

T. Wah, USA

Book—459. Probst, E. H., and Comrie, J., edited by, Civil engineering reference book. Vol. I, II, III, London, Butterworths Scientific Publications, 1951, xii + 1703 pp.

This very carefully edited reference book is not intended to replace textbooks; it presents almost all important branches of the

broad field of contemporary civil engineering. The chapters were written by 50 contributors, mostly British, some from Canada, Austria, Switzerland, Holland, Norway; many of them internationally recognized authorities in particular fields. Chapters of more general interest for engineers are: Strength of materials, Theory of structures, Soil mechanics, Building materials, Surveying, Foundations and earthworks, Steel bridges and structures, Reinforced-concrete structures, Timber construction, Canals and rivers, coasts, Land drainage, Tunnels, Highways, Railways, Waterways, Airports, Harbours and docks, Town planning, Water supplies, Sewerage, Specifications, work construction. Chapters on irrigation and water-power developments are not included. Mechanics of fluids by J. Allen (pp. 158–200) includes dimensional analysis; chapter on canals, channels and rivers by T. Blench treats the design of regime canals.

The editor successfully eliminated overlapping of material in closely related branches. This excellent book can be of great value for civil engineers, not only British.

S. Kolupaila, USA

Book—460. Guerrin, A., Manual on reinforced concrete [Traité de béton armé III], Paris, France, Dunod, ix + 315 pp.

Book consists of three main chapters: first gives short review of the soil mechanics of foundations, the second deals with the dimensioning and design of the structural elements of foundations, third chapter presents some features of special foundation methods.

The first chapter (43 pp) gives, after a general introduction, the computation methods of stress distribution in soils. The treatment is sketchy and orthodox and does not give enough help for practical work. Then, author presents practice and evaluation of loading tests. The main part of the chapter deals with the bearing capacity of soil. The different formulas of bearing-capacity evaluation are presented; reviewer regrets that a clear statement of the assumptions of them is missing. Author points out correctly that bearing capacity is governed by allowable settlements. Numerical examples worked out in detail are a very valuable addition and a great help for the practical designer.

The second chapter (220 pp) forms the most essential part of the book. The design of strip footings, square footings, beam bearing plates, combined footings, mat-type foundations and many other forms of spread foundations have been treated; with stiff and elastic foundations, the real distribution of contact pressures are taken into consideration. Author reviews procedures which have stood the test of practice and experience but takes the modern concepts related to interaction between ground and building into account. The numerical examples and many practical hints (for example, the problems of construction joints, significance of holes in footings, design of special modern forms of footings, etc.) add greatly to the usefulness of this part of the book.

The treatment of pier foundations seems short and many points concerning structure and statical computations are missing. On the other hand, the chapter dealing with pile foundations is more detailed; author surveys the construction and mode of preparation of different pile types, then presents the different methods to determine the bearing capacity of piles. Sound criticism is used on static and dynamic pile formulas. Design of pile caps and mat foundations has been thoroughly treated; this part, too, abounds in practical hints and examples. Reinforced-concrete sheet piling is mentioned, but without statics.

The third chapter deals with practical problems of water-proofing; very valuable is the treatment of construction joints. Chapter ends with foundation of vibrating systems (method of Rausch) and the reinforcing of foundations.

The book is an excellent tool and manual for the practising engineer; many numerical examples and practical hints make it very useful, especially for young designers. In the theoretical field, the material treated is somewhat conservative. Reviewer believes that some features are included for the sake of completeness only, therefore, their treatment is not detailed enough. The design of pneumatic caissons would be, in turn, a very useful addition. The figures are clear and well designed, the style of the text is clear and simple.

A. Kezdi, Hungary

461. Buyer, K., Computation of prestressed reinforced-concrete cylindrical shells used for containers (in German), *Beton u. Stahlbeton.* **52,** 5, 104–111, May 1957.

Prestressing is applied to neutralize traction stresses in wet surfaces in drinking-water containers formed by closed cylindrical shells, flat floor, and flat or curved roof. The computation and analysis of stress of some reinforced-concrete reservoirs built in Germany are given in this paper, which can be useful, in reviewer's opinion, for engineers and designers.

H. Fernandez Long, Argentina

462. Panarin, N. Ya., Stressed state of reinforced and non-reinforced concrete, taking creep into account (in Russian), 13-ya nauch. konferentsiya Leningr. inzh.-stroit. in-ta, Leningrad, 209–212, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5391.

Assuming that the stress at any point of a body and at any moment of creep may be expressed by the relationship

$$\sigma^*(x, y, z, t) = \sigma(x, y, z)\, P(t)$$

where $P(t)$ is determined from the integral equation with a nucleus of creep proposed by N. Kh. Arutyunyan ["Some problems of the theory of creep," M. – L., 1952, p. 47], formulas were obtained for stresses in the reinforcement and the concrete respectively

$$\sigma_a^*(t) = \sigma_a(\tau_1)\left\{1 + \frac{\kappa}{m\tau}\left[1 - e^{-\tau(t-\tau_1)}\right]\right\}$$

$$\tau_\beta^*(t) = \sigma_\beta(\tau_1)\left\{1 - \frac{k}{\tau}\left[1 - e^{-\tau(t-\tau_1)}\right]\right\}$$

Here m is the relationship of the modulus of the reinforcement to the modulus of the concrete, the remaining constants being expressed by the parameters introduced by Arutyunyan.

Also, a formula is obtained which determines σ^* for nonreinforced concrete under the action of a nonsteady flow of heat at an early period.

All the formulas found have an approximate character, since they were obtained as a result of corresponding neutralization.

Courtesy Referativnyi Zhurnal M. I. Rozovskii, USSR
Translation, courtesy Ministry of Supply, England

463. Morozov, N. V., Investigation of strength and stability of thin-walled ferro-concrete panels in respect to compression and shear (in Russian), Investigations of the strength, rigidity and stability of large-panel constructions, Moscow, Gos. izd.-vo lit. po str-vu i arkhitekture, 76–128, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5512.

Results are given of the theoretical and experimental investigations of thin-wall ferro-concrete wall panels of prefabricated large-panel buildings for strength and stability. The investigation of the stability of panels compressed in one direction was effected with consideration of the nonlinear relationship of the deformation of the concrete to the stresses by means of introducing the reduced modulus of elasticity according to Engesser. Also a variant of calculation of the panel for stability was examined which is connected with its representation as an orthotropic plate. The experimental investigations of the panels for uniaxial compression show the close coincidence of the theoretical and test values of the critical stresses in panel walls when the

conventional moduli of elasticity during bending are considered. Bulging of the walls of the panels occurred in two directions according to one half-wave.

A calculation is also given of compressed panels by the method of limiting equilibrium. Experimental investigations made of the panel walls of panels for shear show that the destruction, as was to be expected, comes from the main tensile stresses.

Courtesy Referativnyi Zhurnal G. A. Geniev, USSR
Translation, courtesy Ministry of Supply, England

464. Kuznetsov, V. I., Some modern methods of calculating problems in structural mechanics (in Russian), *Trudi Mosk. vech. Mashinostr. in-ta* no. 2, 184–233, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6241.

Author states his views on the history of the genesis of original parameters. The elements of the statistical theory of stability are examined, to evaluate the stressed condition exactly, and a solution is given of the problem on the stresses with two bodies in elastic contact, when the plane of contact has the shape of an ellipse. I. K. Snitko, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

465. Klechanovskii, A. A., Approximate determination of moment focus relationships of systems having many closed contours (in Russian), *Nauch. tr. Novocherkas. politekhn. in-ta* **26**, 77–86, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5450.

Some views are given which facilitate the approximate determination of focus relationships in the case of the single calculation of closed frames. A. A. Popov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

466. Bergmann, W., Development of airplane parts without stress concentrations, *Jahrbuch Wissenschaft. Gesellsch. Luftfahrt* 183–205, 1956.

First prize winner in a German technical essay contest, author discusses ways of measuring, computing, and avoiding stress concentrations in aircraft parts. The construction members discussed are open sections, the connections of open sections to rigid walls, cutouts in thin-walled cylindrical tubes, both rectangular and circular, T-connections of cylindrical tubes with a variety of gussets and stiffeners, and some miscellaneous rolled sections.

His very thorough experimental analysis is based on brittle-lacquer and strain-gage techniques. Particularly in the case of the T-connection of two thin-walled tubes, author has given extensive stress charts for a variety of designs and loadings. He believes that tests on representative construction assemblies are more valuable than theoretical or experimental stress determinations on very simple shapes.

Some notable findings:

A triangular gusset for the T-joint of two tubes is very poor from the stress-concentration point of view.

A circular hole in a thin-walled tube is best reinforced by a crimp *inside* the tube. E. G. Chilton, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 421, 442, 462, 498, 523, 529, 708)

467. Chudzikiewicz, A., The effect of creep of concrete on composite beam structures (in Polish), *Rozprawy Inz.* **4**, 1, 457–504, 1956.

Using the theory of concrete creep of Dischinger and assuming plane cross sections, computation methods for the effect of concrete creep on statically determinate and indeterminate beam structures are presented.

By means of the method of forces, a system of integral equations is obtained from which the superfluous values can be determined.

D. Niepostyn, Poland

468. Predvoditelev, A. A., and Smirnov, B. A., Theory of dynamic creep (in Russian), *Vestn. Mosk. un-ta* no. 8, 79–86, 1953; *Ref. Zh. Mekh.* 1956, Rev. 5417.

Introducing the assumption of the relationship of the coefficients in formulas given by Becker [*Z. tech. Phys.* **7**, p. 547, 1926] to the speed of deformation, authors obtain an equation for determining the deformation as a function of time. The equation obtained differs from the corresponding relationship obtained by Becker by the presence of a factor which takes into consideration the rate of deformation. Yu. S. Terminasov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

469. Ivanova, V. S., Experiment on an accelerated determination of the protracted creep rate (in Russian), *Zavod. Lab.* **21**, 4, 476–478, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6333.

It is shown that the values of the rate of creep over a period of 1500–2500 hrs, calculated by the formula [I. A. Oding., *Izv. Akad. Nauk SSR, Otd. tekh. Nauk* no. 10, 1948]

$$\epsilon = vt + c\,(p_t/1 + p_t)$$

differ from the experimental figures by not more than a semi-power of ten.

This was the outcome of set experiments with austenitic steel at 550 to 700° and perlitic steel at 480 to 550° over a period of either 300 or 500 hrs. F. S. Churikov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

470. Weir, C. D., The creep of thick tubes under internal pressure, *J. appl. Mech.* **24**, 3, 464–466, Sept. 1957.

Using the usually accepted assumption that the strain rate of a material undergoing creep is given by the product of the stress deviator and a function of the shear-strain energy, and assuming constant density, equations are derived for the creep stresses in a thick-walled tube under internal pressure for a generalized form of the shear strain-energy function. It is shown that these reduce to previously published equations on the substitution of a power law stress-strain rate equation. The nonisothermal case is considered also and creep-stress equations are obtained in a similarly generalized form.

From author's summary by L. Nielsen, USA

471. Hodge, P. G., Jr., Interaction curves for shear and bending of plastic beams, ASME Summer Conf., Berkeley, Calif., June 1957. Pap. 57–APM–19, 4 pp.

General effect of shear on bending in plastic beams is established by determining the interaction curve between bending moment and shear force. This effect is explored for a simply supported rectangular beam and also an I-beam with a concentrated load. It is found that the effect of shear is negligible when the beam length-to-height ratio is larger than about 4 for a rectangular beam and larger than about 8 for the considered I-beam. However, for smaller ratios down to 1, the presented theory should be used for acceptable accuracy. D. Kececioglu, USA

472. Ross, E. W., Jr., On the plane plastic flow of an inset block, *J. appl. Mech.* **24**, 3, 457–460, Sept. 1957.

The yield-point pressure is found for the plane-flow problem of a rectangular metal block, set into a rough entrenchment and squashed from above by a flat, smooth die. The pressure is a

function of both the block width and depth, and, for large ratios of width/depth, approaches the linear pressure variation associated with the Prandtl (cycloidal) stress distribution.

From author's summary by L. E. Nielsen, USA

473. Finzi, L., On the principle of Haar and von Karman in statically determinate problems of plasticity, *J. appl. Mech.* **24,** 3, 461-463, Sept. 1957.

It is shown that a variational formula similar to the one expressing the principle of Haar and von Karman in the statically determinate problems of plasticity holds independently of the stress-strain relations and yield condition. In the variation of the elastic energy the part connected with the variation of the field must be distinguished from the part connected with the variation of the energy density. These points are illustrated by an example.

From author's summary by L. Nielsen, USA

474. Ivanov, Yu. M., Two regions of deformation of wood and the limit of plastic flow (in Russian), *Trudi in-ta lesa Akad. Nauk SSSR* **9,** 431-443, 1953; *Ref. Zh. Mekh.* 1956, Rev. 5599.

The process of deformation of wood which is subjected to an increasing load for a long or short period is divided into two markedly different regions: the region of incomplete elasticity and the region of plastic flow. The stress at which plastic flow occurs at a constant was called the limit of plastic flow by the author as far back as 1938.

In the case of repeated static loading and unloading of specimens at constant rate the value of the limit of plastic flow with increase of the number of cycles should also be reduced, tending to a certain finite value, the limit of static endurance.

This assumption is corroborated by the results of tests with a pulsing load: by the reduction of the value of the so-called assumed limit of endurance with increase of the number of cycles at each stage of the load.

The transition from one region of deformation of wood to another in the case of static and cyclic pulsing loads is connected by the author with the thermal effect in the case of the appearance of irreversible deformation of plastic flow.

Courtesy Referativnyi Zhurnal A. N. Mitinskii, USSR
Translation, courtesy Ministry of Supply, England

475. Tarasenko, I. I., Condition for the destruction of metals (in Russian), *Trudi Leningr. politekhn. in-ta* no. 178, 150-163, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5381.

Paper illustrates the correctness of the law of similarity of stress deviators and relative deformation in the range of considerable plastic deformation to destruction. The coefficient of similarity, which is proportional to the relationship of stress and deformation intensities, is considered dependent not only on the intensity of the deformation, but also on the form of the stressed state. Similarity of the curves $\sigma_i \sim e_i$ is postulated, with a pole at the beginning of the coordinates and a coefficient of similarity dependent on the form of the stressed state. The paper contains no reliably substantiated data for the experimental determination of the relationship in question.

Author devotes much space to proof of the similarity of stress-strain diagrams in various coordinates, though this is previously assumed. M. M. Filonenko-Borodich, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

476. Zaikov, M. A., Influence of the arrangement of a stressed state on the resistance of metal to plastic deformation (in Russian), *Trudi Sibirsk. metallurg. in-ta* no. 1, 130-175, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5366.

An attempt is made to classify possible arrangements of the stressed state and of the explanation of certain assumptions in principle of the theory of plasticity, and also the approximate calculation of typical processes of working metals by pressure (rolling, pressing of bars).

There are a number of elementary errors in the definitions and conclusions in this paper. G. A. Smirnov-Alyaev, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

477. Grubin, A. N., Elasto-plastic problem of torsion of cylindrical rods having a deep annular groove (in Russian), *Sb. nauch. tr. Kyibyshevsk. industr. in-ta* no. 5, 73-81, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5371.

An examination of the problem of elastoplastic torsion of a round rod having a deep (in Neuber's sense) annular groove of hyperbolic profile. At the beginning of the paper, a simple (semi-reverse) solution of the elastic problem, first obtained by Neuber, is given. In this the tangential stress τ_{vw} and the displacement γ_{vw} are equal to zero (a system of elliptic coordinates, u, v, w, is assumed).

It is assumed that $\tau_{vw} = 0$, $\gamma_{vw} = 0$ also in the case of elastoplastic deformation in a very thin layer containing the least section. On the basis of this condition and of the equations of the theory of elastoplastic deformation in the case of stage-hardening (in the plastic zone), the distribution was found for the stresses and deformation in the plane of the least cross section in relation to the value of the torsional moment.

Courtesy Referativnyi Zhurnal L. M. Kachanov, USSR
Translation, courtesy Ministry of Supply, England

478. Polukarpov, G. V., Calculation of ice pressure on frame hydromechanical installations (in Russian), *Trudi Gos. okeanogr. in-ta* no. 23, 24-34, 1953; *Ref. Zh. Mekh.* 1956, Rev. 5505.

When deriving the calculation formula, the ice pressure on a frame is assumed in the form of the sum of pressures caused by the friction of the air against the surface of the ice field, by the pressure of the water and the friction of the water against the underside of the ice. In addition, the force of "weakening" of the ice is calculated; this is connected with its plastic properties.

The formula for the dynamic pressure of the ice is based on the theorem for the amount of motion, on the assumption that the kinetic energy of the drifting ice block is expended on the destruction of the ice; it is assumed that the blocks of ice are laterally limited by cylindrical surfaces, and the impact force depends linearly on the extent of the ice field; the possible deformation of the tube frame (pile) is considered. For the formula derived it is necessary to have the test determination of the coefficients (depth of the incision of the appliance into the ice, temporary resistance, duration of the impact and displacement of the frame according to the loss of water on impact.) S. Ya. Vartazarov, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

479. Gee, R. E., and Lyon, J. B., Nonisothermal flow of viscous non-Newtonian fluids, *Indust. Engng. Chem.* **49,** 6, 956-960, June 1957.

In many chemical engineering operations, viscous non-Newtonian fluids are forced through channels or tubes which are at a temperature different from that of the fluid. Application of accepted engineering design procedures to nonisothermal laminar flow of this type of fluid is very difficult. Effect of various factors on steady-state flow can be determined by solving the equations presented. From authors' summary

Failure, Mechanics of Solid State

(See also Revs. 407, 494)

480. Sub-Committee of Committee on Timber Structures of A.S.C.E. Structural Division, Duration of load and fatigue in wood structures, *Proc. Amer. Soc. civ. Engrs.* **83,** ST 5 (*J. Struct. Div.*), Pap. 1361, 13 pp., Sept. 1957.

Available information on effects of long-time loading and fatigue on the strength and deformation of structural wood is presented by a group of engineers who are most qualified to discuss the subject matter.

The relation of safe working stress to duration of load is given detailed consideration and shown in a chart. Fatigue test data, although of lesser practical importance, are reviewed, and representative S-N curves are presented. Advice is also given on the evaluation of old timbers with respect to their present structural value.

Paper is to form a part of the revised ASCE Manual of Engineering Practice on "Timber piles and construction timbers" to be published at an early date by the Society.

E. G. Stern, USA

481. Garf, M. E., Machine for fatigue testing with a polyharmonic of the stress variation cycle (in Russian), *Zavod. Lab.* **21,** 2, 235–239, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5619.

An analysis is made of the arrangement of a fatigue machine for testing in both bending and torsion, and also their combined action, with a polyharmonic form of the curve of the cycle, as opposed to the harmonic curve of the cycle in ordinary machines.

As a result of the investigation of the machine it was shown that the inertia exciter enables the curve of the loading cycle to be varied within wide limits and that in the system of force measurement there are no considerable distortions because of the inertia of the moving parts of the machine. L. A. Kozlov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

482. Serensen, S. V., and Garf, M. E., Methods of generating dynamic loads as applied to natural tests of machine components for fatigue (in Russian), *Nauch. tr. in-ta mashinoved. i s.-kh. mekhan. Akad. Nauk Ukr. SSR* **5,** 18–39, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5620.

An examination of the basic demands made on loading mechanisms of fatigue machines.

An analysis is made of the arrangements in principle of the following type appliances for generating dynamic loads as applied to natural fatigue tests:
(1) Appliances giving dynamic displacements; (2) appliances directly giving dynamic stresses; (3) appliances with loading of components by the forces of inertia of the natural masses; (4) appliances giving dynamic stresses through an elastic bond; (5) appliances generating stresses variable about a constant stress.

Courtesy Referativnyi Zhurnal D. I. Gol'tsev, USSR
Translation, courtesy Ministry of Supply, England

483. Weibull, W., Statistical handling of fatigue data and planning of small test series, *Flygtekn. Försöksanst. Medd.* 69, 35 pp., 1957.

General regression formulas have been adapted for the purpose of evaluating data from fatigue test series. The concept of linear regression imposes certain particular conditions on the choice of coordinates which have been stated and analyzed.

Formulas for computation of the parameters, including the variance in fatigue strength, have been derived. The variances in the parameters have been deduced for the purpose of setting fiducial limits. The influence of test numbers on the accuracy of the results, and the best apportionment of tests among the stress levels have been discussed.

Five series of 4×9 tests have been produced by random drawing from a large test series of 270 tests. The parameters of each series have been determined. Means, standard deviations, and coefficients of variation have been computed in order to shed some light on the comparative merits of four alternative methods proposed for the determination of the parameters.

From author's summary

484. Suzuki, M., Strain figures appearing on the surface of copper electrodeposits subjected to fatigue, *J. Inst. Metals* **85,** 206–208 + 12 plates, Jan. 1957.

The effects of the microstructure of the underlying metal upon the flecks and strain figures appearing on the surface of electroplated copper subjected to fatigue have been investigated.

Flecks do not occur at random positions, but appear in the region of the grain boundaries of the metal beneath. Moreover, the grain boundaries on which the flecks appear run parallel to the directions of the planes of the maximum shear stress. The maximum shear strain at the surface of the electrodeposited copper coatings below which no flecks occur has a certain limiting value under constant conditions of testing. From author's summary

485. Butler, R. H., and Carter, T. L., Stress-life relation of the rolling-contact fatigue spin rig, *NACA TN* 3930, 23 pp., Mar. 1957.

The rolling-contact fatigue spin rig was used to test balls of a bearing steel at stresses higher than those produced in bearings. Groups of 9/16-in. SAE 52100 grade 1 steel balls lubricated with a mineral oil were tested at 600,000-, 675,000-, and 750,000-psi maximum Hertz stress. The balls were tested at room temperature on fixed tracks that were randomly oriented to the fiber direction of the ball. Plain cylinders of commercial- and vacuum-melt AISI M-1 and commercial-melt AISI M-50 (MV-1) with a bore size ranging from 3.250 to 3.550 inches were used as race specimens.

Stress-life exponents of 10.4 for the SAE 52100 balls and 9.7 for the MV-1 cylinders were obtained. These values are in reasonably good agreement with the values (9 to 10) accepted by the industry. Anomalous results were obtained from a group of AISI M-1 cylinders. Fatigue spalls of subsurface origin similar to those found in complete bearings were obtained. This, plus the agreement in stress-life exponent, establishes the validity of the test for materials comparison and basic investigation of the many factors involved in rolling-contact fatigue. From authors' summary

486. Fisher, W. A. P., Substantiation of safe fatigue life for rotorcraft, *Aero. Res. Counc. Lond. curr. Pap.* 317, 18 pp., 1957.

487. Sinclair, G. M., Corten, H. T., and Dolan, T. J., Effect of surface finish on the fatigue strength of titanium alloys RC 130B and Ti 140A, *Trans. ASME* **79,** 1, 89–96, Jan. 1957.

488. Rice, M. R., Fatigue characteristics of a riveted 24S-T aluminium alloy wing Part II. Stress analysis, *Aero. Res. Lab. Melbourne, Austral. Rep.* SM.247, 11 pp. + 5 tables + 11 figs., Oct. 1956.

489. Rao, M. R. K., and Balakrishna, Y. M., Wear in high-speed diesel engines operating on power alcohol as principal fuel, *J. Ind. Inst. Sci.* **39,** 1, 17–22, Jan. 1957.

Wear tests were conducted with a single-cylinder, direct injection, 5hp, 1500 rpm diesel engine for a period of 1000 hours using power alcohol as principal fuel. During the first 500 hours of the test, an alcohol-water blend (85–15 by vol) was inducted with the inlet air, and neat alcohol was inducted during the remaining period. Throughout the test H. S. D. oil was injected in the normal way to initiate combustion.

It is concluded from these tests that prolonged operation of a diesel engine with neat alcohol as the principal fuel does not lead to any adverse effect on the rate of wear. Besides, there is a noticeable reduction of engine deposits. While the presence of water is conducive to engine cleanliness, it is advisable to restrict its content in the blend because of its adverse effect on wear. From authors' summary

490. Gelman, A. S., and Popov, V. S., Method of determining the residual stresses in butt joints of steel pipes having various coefficients of heat expansion (in Russian), *Zavod. Lab.* **21,** 6, 722–724, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5550.

An examination of a joint by contact welding of two pipes with different coefficients of heat expansion having at the instant of welding the same diameter and the same wall thickness.
Courtesy Referativnyi Zhurnal A. F. Rozhnyatovskii, USSR
Translation, courtesy Ministry of Supply, England

491. Golovanov, S. G., Calculation of the residual stress from cooling processes in steel and cast iron (in Russian), *Vestn. mashinostroeniya* no. 7, 34–38, 1953; *Ref. Zh. Mekh.* 1956, Rev. 5592.

A very conventional calculation of the thermal and residual stresses in steel and cast-iron articles of simple shape is given. In order to judge the danger of accelerated cooling, author introduces the value of the limiting temperature difference at cooling ΔT, which determines the boundary of the start of destruction of the metal. The value ΔT should be determined experimentally.
Courtesy Referativnyi Zhurnal L. A. Glikman, USSR
Translation, courtesy Ministry of Supply, England

492. Frisch, J., and Thomsen, E. G., Residual stresses in cold extruded aluminum, *Trans. ASME* **79,** 1, 155–160, Jan. 1957.

493. Taylor, D. B. C., and Tadros, A. Z., Tension and torsion properties of some metals under repeated dynamic loading, *Instn. mech. Engrs. Proc.* **170,** 33, 16 pp. + 5 figs., 1956.

Two new machines for the testing of metals to fracture under repeated dynamic loading in both tension and torsion are described.

A preliminary series of tests in both dynamic tension and dynamic torsion was carried out on a medium-carbon steel, a mild steel, a silico-manganese spring steel, and two aluminum alloys. For tension, the average time from zero stress to the dynamic yield stress was in the range 0.18–1.00 milliseconds and, for torsion, 0.65–2.67 milliseconds from zero torque to the dynamic yield torque.

In straining specimens to fracture under such repeated dynamic loading, the yield point was found to vary in a manner similar to that for static loading, though all dynamic yield points showed a progressive increase in value with reduction in loading time.

For equal loading times, a greater percentage increase in yield point value was noted for the medium-carbon steel and the mild steel under dynamic torsion as compared with dynamic tension, thus indicating a migration of the criterion of failure away from the Mises-Hencky theory towards the theory of maximum principal stress. From authors' summary by E. A. Davis, USA

Material Test Techniques

(See Revs. 469, 493)

Mechanical Properties of Specific Materials

(See also Revs. 403, 405, 458, 459, 463, 469, 474, 480, 484, 487, 491, 492, 493, 622, 678)

494. Nowinski, J., A series of experiments concerning the effect of scale on the rupture of steel wires (in Polish), *Rozprawy Inz.* **4,** 4, 565–572, 1956.

The scale effect, i.e., the effect on strength of absolute dimensions of structural parts, and the dispersion of the strength itself have a common background due to natural nonhomogeneity of materials.

In already published papers, phenomena having a statistical character are explained for brittle materials. The results of the author's experiments concerning the rupture of 5-cm and 50-cm steel wire samples, 4.5 mm in diameter, lead to the conclusion that the scale effect appears also for nonbrittle materials.
D. Niepostyn, Poland

495. Gardiner, F. J., The spring back of metals, *Trans. ASME* **79,** 1, 1–9, Jan. 1957.

496. Lempriere, B. M., Strengths of Avdel light alloy blind rivets in DTD 546 B sheet, *Coll. Aero. Cranfield Note* 63, 8 pp. + 7 figs., Apr. 1957.

497. Sipple, H. B., and Wald, G. G., Materials and processes for the hot airplane, ASME Semiann. Meet., San Francisco, Calif., June 1957, Pap. 57-SA-72, 8 pp.

498. Marin, J., Mechanical properties of materials for combined stresses based upon true stress and strain, *J. Franklin Inst.* **263,** 1, 35–46, Jan. 1957.

This paper reviews and advocates the use of the "true" or Ludwik stress-strain concepts. It is shown that several alloy steels and aluminum have straight line stress-strain curves when interpreted in this manner and plotted on log-log paper. It is demonstrated, mathematically, that the plastic mechanical properties of materials can be expressed by three parameters: (1) "true" ultimate stress, (2) "true" strain at maximum load (also the strain-hardening exponent), and (3) "true" toughness (area under curve).

It is also proposed that the "true" stress-strain diagram be used as a basis for defining four working stresses, the governing stress being the smallest of these. The four criteria would be obtained from the "true" stress-strain curve and would be physically related to the modulus, yield point, "true" ultimate strength, and the strain-hardening coefficient.

Author makes a particular case for the use of "true" ductility or strain-hardening coefficient. Reference to unpublished work (of 31 materials and 180 "true" stress-strain curves) shows the strain-hardening coefficient to be a measure of "true" ductility.

It is also shown, theoretically, that these concepts may be applied to conditions of combined stress. Because of the complexities of such stresses, however, experimental correlations are not yet available.

Ductility has of necessity been a vague and elusive concept. Author's attempt to place a number upon this property is commendable, and verification of its usefulness by the metal-working industry would be of great value. R. H. Carey, USA

499. Kumarasamy, K., and Burgess, H. J., The nailing properties of 72 Malayan timber species, *Timber Technol.* **65,** 2219, 464–466, Sept. 1957.

The woods, identified by their botanical and trade names, were evaluated on the basis of their resistance to splitting by nails driven near the ends of the test boards, with appropriate marks awarded out of 100 possible marks. E. G. Stern, USA

500. Sadykova, F. Kh., Method of determining the initial moduli of fibers during tension (in Russian), *Nauch.-issled tr. Mosk. tekst. in-ta* **14,** 161–171, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5616.

Not every straight section on the stress-strain diagram of fibers corresponds only to elastic deformation, and consequently may serve for calculation of the modulus of the first kind. At small

loads acting for a short time on the fibers, of the three forms of deformation which make up the whole, the reversible portion predominates: that is, a resilient one and also an elastic one with a small period (10–15) of relaxation. At large loads, the fraction of plastic deformation considerably increases (in this case the part of the elastic deformation in which the period of relaxation exceeds 1 min). It is suggested that the modulus should be calculated according to a conventional relative resilient extension, consisting of the truly resilient together with the aforementioned part of the elastic (with a small period of relaxation), and of the truly elastic and of the load. The minimum value of the load assumed is such that the named reversible portion would amount to not less than 90% for full deformation. The determination of this, the so-called initial modulus, and its value for a series of fibers is described. Preliminary steaming of the fibers in hot water, drying, and conditioning are recommended.

Courtesy Referativnyi Zhurnal V. A. Lepetov, USSR
Translation, courtesy Ministry of Supply, England

Plasticity, Forming and Cutting

(See Revs. 415, 476, 492, 678)

Hydraulics; Cavitation; Transport

(See also Revs. 459, 557, 687, 688, 698)

Book—501. Nagler, J., edited by, The history of engineering [Blätter für Technikgeschichte], no. 15, Wien, Springer-Verlag, 1953, 112 pp. $1.55 (paperbound).

This is the 13th volume of a valuable series on progress of engineering, published since 1932 by the Technical Museum in Vienna. This volume contains 6 contributions, all in the field of hydraulic engineering. E. Salcher sketches the progress of Austrian hydrographic service 1893–1953. R. Ehrenberger reports on the development of hydraulic experimental work in connection with 40 years of the State Hydraulics Laboratory in Vienna. O. Lanser presents two articles: on the history of hydrometric measurements and on the theory and practice of silt transportation investigations. E. Merlicek in "History as a master" demonstrates a failure due to disregarding natural balance. H. Storek reports on history and advancements of the Kaplan turbine. Data from the technical history of Austria to remember during 1954 close this interesting volume.

Article by O. Lanser on hydrometric instruments is of particular general interest. In the biographical remarks, however, several names must be corrected, as R. Woltman, Andreas Rudolf Harlacher, J. A. Eytelwein, L. G. Treviranus, H. Grebenau, J. Amsler-Laffon, A. Staus. Pierre Louis Georges du Buat (1734–1809), author of "Principes d'Hydraulique," is mistakenly identified as his brother Louis Gabriel, comte de Nancay, a diplomat and author. S. Kolupaila, USA

Book—502. Troskolański, A. T., Applied hydromechanics [Hydromechanika techniczna], Hydraulic measurements, Vol. III, Warsaw, Państwowe Wydawnictwa Techniczne, 1957, xxiv + 662 pp.

The third volume [see AMR **9**, Revs. 3633, 3634] is dedicated to hydraulic measurements—hydrometry—in a broad field of application, in rivers, channels and pipes. Physical measurements are not included, nor is the hydrometry of hydraulic structures and machinery. Introduction reviews the elements of measurements: time, angle, length, area, volume, pressure, velocity, discharge. Instruments described are: gages, level recorders, integrometers, containers, manometers, floats, pitometers, current meters, weirs, notches, throats, venturimeters, orifices, nozzles. Theory of current meters and their rating is given with details, as is also Andersson's screen and the danaides. The chapters on water meters in pipelines are particularly extensive. One chapter deals with hydraulic laboratories, designed for testing of water meters.

Index of subjects with equivalents in English, French, German, and Russian, on 102 pages, is a very valuable addition to this important treatise, the most complete in modern literature. A few details of historical interest could be improved: proportional (hyperbolic) notch was invented by American O.V.P. Stout in 1897, not by M. Rother in 1921; A. Barbagelata called his method chemical-electric, not electrochemical.

S. Kolupaila, USA

503. Benjamin, T. B., On the flow in channels when rigid obstacles are placed in the stream, *J. fluid Mech.* **1**, 2, 227–248, July 1956.

Author uses three physical quantities Q, R, S introduced in a previous paper [see Benjamin, T. B., and Lighthill, "On cnoidal waves and bores," *Proc. roy. Soc.* (*A*), **224**, 448–460, 1954] with the meaning

$$Q = vh, \qquad R = \frac{1}{2}v^2h, \qquad S = v^2h + \frac{1}{2}gh^2$$

i.e., Q is the flow rate, R the energy for unit mass, and S the momentum flow rate for unit span (corrected for changes in horizontal pressure force due to changes in depth) and divided by density. Invariability of these quantities at different cross sections implies, respectively, conservation of flow rate, energy, and momentum.

The present paper is divided in five parts: 1 - Introduction; 2 - General theory of flow; 3 - Flow under a sluice-gate; 4 - Flow under a planning surface; 5 - Experimental tests.

Parts 1 and 2 deal with some properties of flow and waves. Reviewer remarks that a more careful use of the conditions Q = const and S = const would be desirable. For instance, if we consider surface waves, Q is constant in every cross section if coordinates are fixed with the crest (i.e. when $v = 0$), but with this condition it is impossible to have S = const.

In the three last parts, author studies the flow under a vertical or inclined gate, but it seems that new results are very small. In fact, author does not know some papers written with the same purpose. For instance we must recall the Italian papers of Gentilini [*Energia elett.* April and June 1941] and Marchi [*Ann. Mat. pura appl.* (*IV*) **34**, 1953]. G. Supino, Italy

504. Szesztay, K., Computation of the velocity of flow (in Hungarian), *Viz. Közl. no. 1/2, 22–61, 1957.*

After a comparison of several existing formulas for flow in open channels and conduits, author analyzes the modern formulas by Colebrook and White (1939), revised by Lamont (1954) and Cramp (1956). Author derives a simplified formula for established turbulent region and prepares a set of nomograms for convenient practical use. S. Kolupaila, USA

505. Rozovsky, I. L., Flow investigation at the bend of a channel (in Russian), *Izv. in-ta gidrol. i gidrotekhn. Akad. Nauk Ukr. SSR* **12**, 58–77, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5182.

A short survey is given of investigations previously made of the motion of a flow at the bend of a channel, and the results are explained of the laboratory tests made in the Institute of Hydrology and Hydromechanics of the AN Ukr. SSR. on two models: a wooden one with a channel of rectangular section of a width of 0.8 m, curved by 180° according to the arc of a mean radius of 0.8 m, and a concrete one with a channel of complicated cross section, nearly parabolic, with a width at its summit of 2.0 m, a maximum depth of 0.2 m, and an axis bent through 90% over an arc of a

radius of 5.0 m. Results are given of the actual investigations made by the same institute in 1952 on the bend of the River Desna.

Investigations show that, both on the models and in the channel of the river, one-sided circulation is noted with surface speeds directed outward from the center and bottom speeds directed toward the center of the curve. A peculiarity of the circulation in the river flow is a decrease of the transverse velocities with approach to the bottom, a fact which was not noted in the trough with a smooth bottom.

A comparison was made of the theoretical formulas of the author, of M. V. Potapov [*Visti In-tu gidrol, i gidrotekhn AN Ukr RSR* 1950, 6 (XIII)], K. I. Rossinsky and I. A. Kuzmin [S. N. Kritsky, M. F. Menkel. "Hydrological bases of river hydromechanics," Izd.-vo AN SSSR 1950], and of V. M. Makkaveer [*Tr. Gos. Gidrol. in-ta* 1948, (8) (69)] for determining the transverse velocities of the bend of a channel with the data of laboratory and river tests. Comparison shows that the best results are given by the author's formula which he obtained for a wide channel on the basis of the assumption of the logarithmic law of distribution of the longitudinal velocity relative to the vertical; for models, with a parameter of the logarithmic formula of $K = 0.5$, and for the river Desna, with $K = 0.33$.

It is shown that, for river flows, the parameter of the logarithmic formula K varies within wide limits, and, as a result of the uncertainty of the factors which determine its value, it can only be obtained by means of the analysis of measured data.

Courtesy Referativnyi Zhurnal O. L. Yushmanov, USSR
Translation, courtesy Ministry of Supply, England

506. Gumbel, E.-J., Graphical methods of flood discharge analysis (in French), *Houille blanche*, **11**, 5, 709–717, Nov. 1956.

This graphical method uses probability paper and enables the periods after which floods recur to be determined.

Results are compared with observations. The theory of extreme values is discussed. Application is made to flood discharges. Author estimates parameters to be used. Flood discharges in various water courses are compared.

Discussion of paper concerns: Hypothesis of an unbound field of variation for the distribution of flood discharges; theoretical remarks on the speed at which it converges to the asymptotic law; possible errors due to the application of graphical method to flood discharges.

Mr. Bernier comments on the general limiting forms of the law of the greatest value of a sample of N independent random variables. He remarks concerning the convergence of the extreme values toward limiting laws; types of laws: (a) normal; (b) Laplace; (c) Galton-Gibrat. Properties of and adjustments for Frechet's law are given. From author's summary

507. Mikhailovsky, V. N., and Danilyuk, I. S., Problem of the control of the discharge and amount of water in channels of irrigation systems (in Russian), *Nauch. zap. in-ta mashinoved. i avtomatiki Akad. Nauk Ukr. SSR* **4**, *Ser. Avtomatiki i izmerit. tekhn.* no. 3, 126–235, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5185.

Views are given relating to the direction and a program of work on automation and remote control of irrigation systems, and a solution is also given of the first point of this program, that is, the choice of the design elements of the measuring instrument and the quantity of water in canals and examination of its design and characteristics.

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

508. Andriyashev, M., Approximate formulas for the hydraulic calculation of pipelines (in Russian), *Zhil-kommun K-vo*, no. 3, 22–23, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5176.

Mononomial formulas are suggested for determining the resistance coefficient in the case of nonquadratic and quadratic relationships of pressure loss to velocity.

The numerical values of exponents and coefficients are shown in the attached tables applied to the calculation of pipeline systems for cast iron, steel, and asbestos-cement pipes.

Courtesy Referativnyi Zhurnal P. G. Kiselev, USSR
Translation, courtesy Ministry of Supply, England

509. Pozdnyakov, I. T., and Sapozhnikov, M. M., The investigation of the hydraulic characteristics of glass pipelines (in Russian), 13-ya nauch. Konferentsiya Leningr. inzh. stroit. in-ta, Leningrad, 1955, 129–131; *Ref. Zh. Mekh.* 1956, Rev. 5901.

A brief description is given of the method used in the experiments with glass tubes of 100, 38 and 13.2 mm. On the basis of their own investigation and those on glass tubes of 56.8 mm carried out by the Mossoveta institute, a relation was obtained $\lambda = K/R^m$, where K varies between 0.0861 and 0.38, and m between 0.25 and 0.13; Reynolds number varied within the region 3780 to 229,500. In addition, data are furnished to determine the coefficient of local resistance for joints.

Courtesy Referativnyi Zhurnal B. K. Konopkii, USSR
Translation, courtesy Ministry of Supply, England

510. Morgenshteri, V. S., The application of Bernoulli's equation to the solution of the problem on the irregular movement of water in round pipes (in Russian), *Vodosnabzhenie i san. tekhnika* no. 9, 17–20, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5904.

To simplify the calculations of the hydraulics concerned when there is irregular flow of water in circular pipes, with the help of Bernoulli's equation, tables have been made for the critical discharge and also the expressions

$$\frac{\alpha}{2g}\left[(1/\omega_2 2) - (1/\omega_1 2)\right], \quad K^2 = (\omega c \sqrt{k})^2$$

depending on the degree of fullness of the pipe. Here α is the coefficient of the velocity of thrust (Comelius coefficient), ω_2, ω_1 the areas of the cross sections of the flow, k the average discharge characteristic for the given computed section.

Courtesy Referativnyi Zhurnal P. G. Kiselev, USSR
Translation, courtesy Ministry of Supply, England

511. Osborn, D. F., Control of water hammer in an 8-inch diameter pumping main, *Trans. S. African Instn. civ. Engrs.* **7**, 6, 203–216, June 1957.

Paper draws attention to the considerable reduction of surge pressures and the consequent saving of material in pipelines resulting from the use of air vessels on pumping mains. Comparisons are drawn between the theoretically predicted pressure fluctuations and those actually measured at several points in an existing installation, both with the air vessel connected and with the air vessel isolated.

For the sake of clarity in discussing discrepancies between theoretical and actual pressures, the water-hammer phenomenon is outlined and the graphical analysis is explained in some detail, using the actual values.

With the air vessel isolated, separation of the water column hampers the comparison but illustrates the result of this phenomenon and the efficacy of the air vessel in preventing it.

From author's summary

512. Liu, H-K., Mechanics of sediment-ripple formation, *Proc. Amer. Soc. civ. Engrs.* **83,** HY2 (*J. Hydr. Div.*), Pap. 1197, 24 pp., Apr. 1957.

Sediment ripples are explained as caused by the instability of a transition layer between the fluid and the bed. A new criterion is

introduced, so-called movability number of sediment particles, u^*/w, the shear velocity ratio to the fall velocity of particle. This number was plotted as a function of the critical Reynolds number; the shear velocity and the diameter of particles or absolute roughness are used in this number. Author had performed experiments with two types of sand in the St. Anthony Falls Hydraulics Laboratory in Minneapolis. His results, as also those of several earlier experimenters, show a close agreement with an established graphical relationship. Paper is a successful step toward solution of this complex problem.

S. Kolupaila, USA

513. Zienkiewicz, O. C., Stability of parallel-branch and differential surge tanks, *Instn. mech. Engrs. Proc.* **170,** 7, 265–280, 1956.

514. Gorbatova, A. N., Laboratory investigations of the conditions of hydraulic rupture of the seam (in Russian), Thesis, Azerb. industr. in-ta, Baku, 1955; *Ref. Zh. Mekh.* Rev. 5336.
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

515. Whippen, W. G., and Johnson, G. D., A high head cavitation test stand for hydraulic turbines, *Proc. Amer. Soc. civ. Engrs.* **83,** HY 2 (*J. Hydr. Div.*), Pap. 1201, 8 pp. + 5 figs., Apr. 1957.

Incompressible Flow: Laminar; Viscous

(See also Revs. 573, 574, 578, 584, 586, 596, 603, 618, 630, 685, 687, 688, 691)

516. Meyer, R., Method of obtaining actual flow patterns with low energy loss (in French), *Houille blanche* **12,** 8, 303–315, May–June 1957.

Irrotational flow patterns of a perfect fluid (particularly since the development of the method of Barillon, Danel, Sauvage De Saint-Marc, etc.) have formed an "intuitive" basis for the hydraulic engineers. In fact, actual flows are, in general, quite different from irrotational flows. This article (1) shows that many actual flows encountered in industry are little different from rotational flows of a perfect fluid; (2) describes a method of graphically drawing fluid rotational flows which are either two-dimensional or which can be rendered two-dimensionally; (3) describes certain interesting deductions which can be made from these drawings.

From author's summary

517. Landweber, L., and Yih, C. S., Forces, moments, and added masses for Rankine bodies, *J. fluid Mech.* **1,** 3, 319–336, Sept. 1956.

Paper is concerned with generalization of methods for computing forces and moments on solids moving steadily or unsteadily in incompressible and inviscid fluid. Problem is attacked by methods of Kirchhoff-Taylor (forces and moments expressed in terms of added masses; these, in turn, expressed in terms of the flow-simulating singularities) and of Lagally (forces expressed directly in terms of singularities). Useful, fairly complete development of problem is given, with compact notation employing summation convention.

In Kirchhoff-Taylor approach, extension to flows with boundaries or other bodies is made. A theorem concerning form of added mass coefficients for pure rotation is proved, and some results for special bodies given, including approximate ones for elongated bodies. Momentum and moment of momentum are calculated.

Results of Cummins [AMR **7,** Rev. 840] are rederived in extended (to include isolated doublets), compact form. Comparison of the two approaches by calculation of forces is made. An example is worked. Paper is a useful and interesting contribution.

F. B. Fuller, USA

518. Carrier, G. F., On the torsional oscillations of a solid sphere in a viscous fluid, *J. appl. Mech.* **23,** 4, 601–605, Dec. 1956.

When a solid sphere rotates steadily or harmonically in a viscous fluid the combination of viscous and centrifugal forces causes fluid to be steadily sucked in along the axis and then thrown out along the equatorial plane of the sphere. A laborious successive approximation scheme is set up for the solution of the Navier-Stokes equations in spherical coordinates and carried out to the second power of the amplitude of the angular displacement ϵ (radians). One of the conclusions of interest in viscosimetry is that, for large values of the unsteady Reynolds number, $R(2\omega/\nu)^{\frac{1}{2}}$, ($R$ sphere radius, ω angular velocity, ν kinematic viscosity), the correction to the classical viscous torque on the sphere (which disregards the centrifugal force) is approximately $4\epsilon^2\%$.

M. V. Morkovin, USA

519. Cooke, J. C., The flow of fluid along cylinders, *Quart. J. Mech. appl. Math.* **10,** 3, 312–321, Aug. 1957.

The problem of the laminar boundary layer on a cylinder without corners is treated by several methods. By transforming the boundary-layer equations into a series of linear third-order differential equations, it is found that the first three equations of the series agree with those previously found for the circular cylinder. The Kármán-Pohlhausen method of solution also agrees with first three terms of the solution for the circular cylinder. The Rayleigh method is used to find the drag for large distances from the leading edge. The results lead the author to believe (not proved in paper) that the circular cylinder has the largest drag of all closed cylinders with the same perimeter.

W. Daskin, USA

520. Khazhaliya, G. Ya., Steady motion of a liquid in a pipe which is not quite cylindrical (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **95,** 3, 465–468, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5174.

Examination of the axially symmetrical motion of a liquid. The x axis is taken as the axis of the symmetry, and the surface $x0y$ is the axial section of the flow. The rate of flow is determined at its border $y = y(x)$ on the following assumptions: (1) At a finite mean rate of flow the values $y(x)$, $y'(x)$, $y''(x)$, $y'''(x)$ are considered uniformly small relative to x; (2) The rate of flow V is determined at the boundary point, which retains only terms of the second degree relative to $y(x)$, $y'(x)$, $y''(x)$.

By examining certain particular motions, author finds the following equation for the required solution

$$V = \frac{b}{\pi y^2}\left[1 + \frac{1}{4}yy'' - \frac{1}{4}y'^2\right] \qquad [1]$$

in which b denotes the delivery of liquid. This formula is used for determining steady motion in an elastic cylindrical pipe with the given delivery b at a given static pressure in the liquid. Formula [1] represents a generalization of a formula of M. A. Lavrentiev for determining the dilation in the case of conformal representation of a narrow strip on a rectilinear one [M. A. Lavrentiev, "Conformal representation with applications to some problems of mechanics," Moscow, Leningrad, Gostekhizdat, 1946, 109 pages].

Courtesy Referativnyi Zhurnal A. I. Kalandiya, USSR
Translation, courtesy Ministry of Supply, England

521. Samogonyam, A. Ya., and Bagdoev, A. J., The penetration of a cone into a liquid with a free surface (in Russian), *Vestnik Mosk. un-ta* no. 8, 47–52, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5883.

A circular-based cone sinks into an incompressible, imponderable, theoretically ideal liquid, taking up the lower half of the area. The boundary conditions on the free surface are transferred to the plane of the undisturbed level of the liquid. The immersion continues as in a mirror into the top part of the area. On the surface of the submerged part of the cone and on its mirror reflection

bubbles are formed. An equation is found, that of Fredholm with a complicated nucleus, for a compact distribution of ripples q. An equation is given for the movement of the cone on the assumption that the force exerted by the weight of the cone is disregarded. In the formation of the equation for this movement, author likewise disregards the fact that the wetted surface of the cone will be greater than that of its submerged part, in consequence of the rise of the liquid round the cone [compare Wagner, *ZAMM* no. 4, 1932]. For an infinite thin cone, the integral equation for q is solved simply. The equation for the motion of the cone is also given, and a numerical example is calculated. M. I. Gurevich, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

522. Burgvin, A. G., On one aspect of the equation for the movement of viscous liquid (in Russian), Parovye dvigateli, Moscow, Mashgiz, 1955, 28–32; *Ref. Zh. Mekh.* 1956, Rev. 5967.

An equation has been evolved with the help of known methods of vector analysis to determine the function of flow relating to the plane-parallel movement of a viscous, incompressible liquid, in the case where the rotation with a variable angular velocity of the moving system is a coordinate relative to the fixed axis.

Notes by the Abstractor: To solve the case put forward in the article, the following formula is applied in textbooks on hydrodynamics, which links up the function of flow in both absolute and relative movements of the liquid,

$$\phi_a = \phi_r - 1/2\,\omega(x^2 + y^2)$$

By substituting this expression for the known equation for the function of flow ϕ_a, one at once obtains Eq. 14 of the article.
Courtesy Referativnyi Zhurnal N. A. Slezkii, USSR
Translation, courtesy Ministry of Supply, England

523. Jabotinsky, E., A tentative explanation of the Weissenberg and Reiner effects by postulating the existence of gyroscopic phenomena in viscous flow, *Bull. Res. Counc. Israel* **6A,** 1, 65–76, Oct. 1956.

Gyroscopic effects in viscous flow are postulated, resulting in the splitting of the flow into separate spinning portions. The spin of each portion is given for incompressible flow by the gyro-spin equation, which is used to show that the Weissenberg-Reiner effects can be expected for values of $\Omega^2 rb$ satisfying a double inequality. The radial distribution of pressures is predicted.
From author's summary

524. Binnie, A. M., Experiments on the slow swirling flow of a viscous liquid through a tube, *Quart. J. Mech. appl. Math.* **10,** 3, 276–290, Aug. 1957.

To investigate the nature of the flow pattern when swirling water passes slowly through a long, straight, and transparent tube, a short length at the middle of the tube was caused to revolve, and through numerous holes in this portion the water was admitted under gravity. Color injection was employed and, just clear of the rotating length, three alternative regimes were seen: (1) downstream over the whole cross section; (2) upstream near the axis and downstream near the wall; (3) downstream near the axis and the wall and upstream in the intermediate region. For four different arrangements of blockage in the two fixed lengths of tube, the results are plotted on diagrams having for their axes two dimensionless quantities that depend respectively on the tangential velocity at admission and on the mean axial velocity through the tube. When one of the fixed lengths was blocked close to the revolving part and color was injected through the holes nearest to the blockage, the result under some conditions was three streams, symmetrically disposed 120° apart, that passed through the other fixed length. From author's summary

525. Kharlamov, P. V., Forward motion of a heavy solid in a liquid (in Russian), *Prikl. Mat. Mekh.* **20,** 1, 124–129, Jan./Feb. 1956.

526. Schmidt, A. O., and Weiter, E. J., Flat-surface friction apparatus, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-48, 10 pp.

527. Kogan, M. N., Theory of flow around bodies of small elongation (in Russian), *Prikl. Mat. Mekh.* **20,** 1, 87–94, Jan./Feb. 1956.

528. Pai, S.-I., Energy equation of magneto-gas dynamics, *Phys. Rev.* (2) **105,** 5, 1424–1426, Mar. 1957.

The general energy equation of a viscous, heat-conducting, and electrical-conducting fluid in magneto-gas dynamics has been derived. Various simplified forms of energy equations have been discussed, particularly for the cases with magneto-gas dynamic approximations. The fundamental equations of magneto-gas dynamics are also given. From author's summary

529. Armstrong, W. D., The secondary flow in compressor blades at high negative incidences, *Aero. Res. Counc. Lond. curr. Pap.* 297, 2 pp. + 6 figs., 1956.

530. Mainwood, G. J., The velocity distributions round elliptic sections due to thickness and angle of attack, *Nat. Res. Counc. Canad. mech. Engng. Rep.* MB-193,12 pp. + 6 tables + 8 appendixes, Oct. 1956.

Ordinates for elliptic sections of given thickness-length ratios are derived and tabulated, together with the velocity distributions round such sections due to thickness and angle of attack. The N.A.C.A. process of superimposing these velocities, together with the velocity resulting from camber is incidentally verified for sections of small thickness-length and camber ratios. A comparison is made between the velocity distributions round an elliptic section and those for the N.A.C.A. 16-series thickness distribution.
From author's summary

531. Senecal, V. E., Fluid distribution in process equipment, *Indust. Engng. Chem.* **49,** 6, 993–997, June 1957.

Future process design needs better control of circulating fluids. Solutions are suggested here for several types of nonuniform distribution problems. From author's summary

Compressible Flow, Gas Dynamics

(See also Revs. (555, 564, 567, 570, 572, 576, 577, 588, 594, 625, 678, 708)

532. Woods, L. C., Compressible subsonic flow in two-dimensional channels, I, II, *Aero. Quart.* **6,** 3, 205–220, Aug. 1955; **6,** 4, 254–276, Nov. 1955.

The two-dimensional irrotational flow of a compressible gas with $\gamma = -1$ is considered. Formulas for channel design are explicitly given and an iterative scheme is proposed for the calculation of the flow through a channel of a given shape. Special formulas are also given for an interesting class of channel flow problems where one wall is a constant pressure streamline while the other either has a known shape or pressure distribution. The theory is in essence similar to that given by F. H. Clauser (who showed how a great variety of problems can be treated by the complex variable technique for a gas with $\gamma = -1$).

In part II, the theory of part I is applied to the following problems: (1) Flow through channels with rectilinear walls; (2) design of a channel with sectionally constant wall pressures; (3) flow of a stream up a step; (4) flow about a circular cylinder in a channel

with a constant pressure wall or a straight wall; and (5) the important problem of setting of "streamline" walls about a symmetrical airfoil placed in the center of a flexible wall wind tunnel.

B.-T. Chu, USA

533. Mangler, K. W., and Spencer, B. F. R., Some remarks on Multhopp's subsonic lifting-surface theory, *Aero. Res. Counc. Lond. Rep. Mem.* 2926, 9 pp., 1956.

In R and M no. 2884, "Methods for calculating the lift distribution of wings—(Subsonic lifting-surface theory)" [AMR **9**, Rev. 4031], H. Multhopp describes a procedure for calculating the lift distribution on thin subsonic wings. Early methods based on the lifting-line theory worked reasonably well on unswept, high aspect-ratio wings. The trend toward low aspect-ratio swept wings required improvements on the lifting-line theory in the direction of a surface distribution of lifting doublets. The unknown doublet strengths must be integrated to give the slope of the velocity vector which then is matched to the slope of the wing at its surface. The resulting integral equation can be solved by making suitable assumptions on the approximate form of the doublet distribution.

The method proposed by Multhopp consists basically in integrating the downwash due to doublets at certain "pivotal stations." The chordwise integration is performed first with the aid of functions which have been tabulated for this purpose. The resulting influence coefficients are then integrated spanwise using techniques borrowed from lifting-line theory. The results can be made arbitrarily precise by selection of sufficiently large number of pivotal stations. The use of the tabulated functions and the judicious selection of pivotal points produce accurate results with a tolerable amount of labor. Multhopp's method is therefore widely used, and modifications or extensions can be significant.

One such modification concerns the step in the calculation by which Multhopp corrects for a logarithmic singularity around the pivotal point appearing in one of the integrals. Multhopp added a correction term to the function which interpolates downwash distribution between stations. The correction term, when integrated, accounts for about 5 to 10 per cent of the total downwash.

Mangler and Spencer, on the other hand, show that a trigonometric interpolation formula leads to integrable functions and hence provides a sounder basis for computing the effect of the logarithmic singularity. Although the numerical difference between the two methods is generally quite small, that of Mangler and Spencer is favored (even by Multhopp) because it gives a basically better answer with no extra work.

L. H. Schindel, USA

534. Lifshits, A. G., On the transformation of the velocity of the gas into pressure in a diffuser (in Russian), *Trudi. Ural'skogo politekh. in-ta* no. 41, 112–116, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5849.

The performance of a subsonic diffuser was investigated hydraulically. The results of the calculations are given.

Courtesy Referativnyi Zhurnal D. A. Mel'nikov, USSR
Translation, courtesy Ministry of Supply, England

535. Keune, F., Unified representation and extension of the equivalence rule for transonic flow (in German), Forschungsberichte des Wirtschafts-und Verkehrsministeriums Nordrhein-Westfalen no. 316, 1956.

According to the equivalence rule (due to Oswatitsch and Keune, AMR **8**, Rev. 1097) properties of subsonic, transonic, and supersonic flows over slender bodies can be determined, if the flow over an axisymmetric body with the same area distribution is known. This paper is a careful summarizing representation; it discusses the theoretical foundations, methods for practical computations, and relations to similar work, particularly to Withcomb's area rule. Leading ideas are presented in a descriptive first part, details in a second part.

G. Guderley, USA

536. Korst, H. H., A theory for base pressures in transonic and supersonic flow, *J. appl. Mech.* **23**, 4, 593–600, Dec. 1956.

Problem considered is that of calculating base pressure for steady, two-dimensional, turbulent flow. Method involves four essential steps: (1) Mixing-length-type theory used to calculate velocity distribution within separated layer; (2) momentum-conservation integral used to determine velocity $\bar{u}$ along "discriminating" streamline leaving edge of base; (3) total pressure on discriminating streamline approaching reattachment zone equated to static pressure downstream; and (4) use of oblique shock relationships across trailing shock wave. Detailed calculations are carried out for case when turbulent boundary layer approaching base is of negligible thickness. Excellent agreement with experiment is obtained.

Reviewer notes that subject analysis for fully turbulent flow is similar to subsequent, independent analysis of reviewer for fully laminar flow [*NACA TN* 3869] which leads to excellent agreement with measurements on separated laminar flows. Steps (1) and (4) differ, but the essential idea is step (3) and is common to the two analyses. Idea behind (3) is believed essential to understanding of many types of separated flow.

D. R. Chapman, USA

537. Spreiter, J. R., and Alksne, Alberta Y., Thin airfoil theory based on approximate solution of the transonic flow equation, *NACA TN* 3970, 82 pp., May 1957.

A method is presented for the approximate solution of the two-dimensional nonlinear equations of transonic small disturbance theory. The nonlinear equations are linearized in a small region by replacing part of the nonlinear term by a constant; this linearized equation is solved by standard methods and the result is put into such a form that a first-order nonlinear ordinary differential equation is obtained upon substituting for the constant the quantity it originally replaced; the ordinary differential equation is consecutively solved analytically. The accuracy of this approximation method is investigated.

Results for the pressure distribution are presented in closed analytic form for a large and significant class of nonlifting airfoils at Mach number near 1 and for purely subsonic and purely supersonic flows. The inverse problem of determining the shape of the airfoil having a prescribed pressure distribution is also treated.

Extensive comparisons are made with experimental and theoretical data of other authors. The comparisons show that the present authors have given an elegant theory, which is in good agreement with experiment.

E. M. de Jager, Holland

538. Nocilla, S., Transonic flow field around a symmetrical wing with zero angle of attack (in Italian), *Monogr. Lab. Aero. Politecn. Torino* **90**, 367, 17 pp., May 1955.

539. Henshall, B. D., An index of mathematical tables for shock-tube flow, *Aero. Res. Counc. Lond. curr. Pap.* 292, 6 pp. + 1 fig., 1956.

540. Franks, W. J., Interaction of a shock wave with a wire screen, *Univ. Toronto Inst. Aerophys., UTIA Rep.* 13, iii + 18 pp. + 21 figs., May 1957.

Interferometric and wave-speed schlieren pictures were taken for plane shocks impinging on wire-gauze screens. It was noted that, for weak incident shocks, this encounter results in the emergence of a reflected shock traveling upstream and a transmitted shock traveling downstream followed by a contact surface. For stronger incident shocks, the flow becomes choked. Thus in addition to the reflected and transmitted shocks, the supersonic flow immediately behind the screen is terminated by a secondary normal shock which follows the contact surface downstream.

A simple computation based on one-dimensional quasi-steady model according to observed wave pattern was carried out. The predicted strengths of transmitted and reflected shocks, and the choking Mach numbers are found to be in good agreement with experimental results. H. S. Tan, USA

541. Chang, C.-T., Interaction of a plane shock and oblique plane disturbances with special reference to entropy waves, *J. aero. Sci.* **24,** 9, 675–682, Sept. 1957.

Interaction between a plane entropy wave and a plane oblique shock is investigated. In the perturbed flow field downstream of the shock, three kinds of disturbances are present, namely, an entropy mode, a vorticity mode, and a sound mode. The nature of the sound wave generated depends on the orientation of the upstream disturbance. Within certain orientations, the sound waves generated downstream attenuate. Beyond these orientations, the sound waves generated have constant amplitudes. When the downstream sound waves are not attenuated, there is no phase shift in the entropy disturbance across the shock; when the downstream sound waves are attenuated, a phase shift occurs in the entropy disturbance across the shock.

From author's summary by W. C. Griffith, USA

542. Bleviss, Z. O., Some integrated volume properties in linearized flow and their connection with drag reduction at supersonic speeds, *Douglas Aircr. Co. Rep.* SM-19469, 58 pp., Feb. 1956.

Some theorems relating distributions of force and volume elements to local and total body volumes are developed on the basis of potential (and, for the most part, linearized) flow theory.

H. Lomax, USA

543. Brun, E. A., Aerothermodynamics seminar of the Faculty of Sciences of Paris (in French), *Publ. sci. tech. Min. Air, France* NT 63, 110 pp., 1957.

This seminar included the presentation of eight original papers covering a wide variety of fundamental concepts and measurement techniques in the field of aerothermodynamics. The following papers were presented: "Sweat cooling of walls" by Jean Berger; "Heat transfer in liquid metals flowing in tubes" by Marcel Robin; "Heat transfer from a body moving in a rarified gas" by Marcel Devienne; "Some applications of the theory of limits of diffusion" by Adalbert Ondart; "Natural convection in the region of a hot sphere" by Pierre Vernotte; "The use of the interferometer in the analysis of stream flow" by P. Guienne and F. Bouniol; "The velocity profiles of a compressible fluid in flow" by Gerard Gontier; and "A study of investigative techniques for a compressible fluid" by Max Plan.

Space does not permit even a concise review of the diverse material presented in the eight papers. The collection represents a valuable contribution of new ideas and re-examination of well-known concepts and experimental techniques. J. F. Lee, USA

544. Luther, M., Fixing boundary-layer transition on supersonic wind-tunnel models, *J. aero Sci.* **24,** 8, 579–586, Aug. 1957.

Limitations in size and power of supersonic wind tunnels and other requirements usually cause model tests to be performed at Reynolds numbers much lower than those of prototype aircraft or missile. Boundary layer of model may be partly or wholly laminar, instead of turbulent, as in prototype. Consequently, skin-friction, drag, rate of growth of boundary layer, separation and effectiveness of control surfaces may be different than for prototype. Artificial methods are used to fix transition to turbulent flow on model, as a means to simulate prototype conditions.

Paper reports series of experiments made at Jet Propulsion Laboratory of California Institute of Technology during 1954–1955 on transition for cone-ogive-cylinder models of 10.6 fineness ratio, and at supersonic speeds. Use was made of 20-in. (51-cm) wind tunnel at Mach numbers 1.62, 3.07, 4.09, and 5.04. Roughness was added at tip of cones attaching wire elements or carborundum grits.

Principal purpose of tests was to obtain critical roughness-element height k_c, i.e., minimum height able to produce transition at or very near the roughness element. Plots of k_c versus Mach and Reynolds numbers are presented. Rapid increase of k_c with Mach number was noted, specially for low Reynolds numbers. Also, for same roughness height, and same station, distributed roughness was found more effective than single-element roughness, this difference decreasing with increase in Mach number. Increases in k_c were observed with increase in cone angle, for the higher Mach numbers. Transition point was determined from spark-schlieren photographs and from drag data. Several typical schlieren photographs are presented in paper. Author concludes that for ranges of variables tested, both types of roughness can be satisfactorily used in fixing transition, "with negligible effect due to roughness itself on the drag (apart from that attributed to movement of the transition point)." A. Balloffet, USA

545. Naylor, D., The aerodynamic action of triangular horn-balanced control surfaces on the supersonic delta wing, *J. aero. Sci.* **24,** 8, 274–278, Aug. 1957.

The pressure distribution of a supersonic delta wing in the region of influence of a deflected flap type of control with a triangular horn balance is determined on the basis of linearized theory. Both subsonic and supersonic leading edges are considered. General formulas for the control-hinge-moment increments are calculated to estimate the effectiveness of an aerodynamic balance of the type considered, and corresponding formulas for the increment in the lift are also developed.

From author's summary by H. Mirels, USA

546. Fogel', Ya. M., Lisochkin, G. A., and Stepanova, G. I., The supersonic emission of mercury vapour in a vacuum (in Russian), *Zh. tekh. Fiz.* **25,** 11, 1944–1953, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5848.

An investigation is made of the possibility of using the supersonic jets of vapor emitted in a vacuum, in the nature of a target, for the formation of ionic clusters. The experiments and calculations made in this study show that such a possibility might come to function.

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

547. Broude, B., Apparatus for the study of streamlined bodies when flying at supersonic speeds (in Russian), *Grazhd. aviatsiya* no. 10, 27–28, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6106.

A description is given of a simple apparatus to demonstrate the analogy between the flow of water in a thin layer with a free surface and a flat flow of gas, if the bodies being streamlined in both cases are geometrically similar and are located the same way. A special feature of the apparatus is the possibility of projecting on a screen a picture of the streamlining, obtained by illuminations through the layer of water. S. G. Popov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

548. Bennett, F. D., Note on tip-bluntness effects in the supersonic and hypersonic regimes, *J. aero. Sci.* **24,** 4, 314–315, Apr. 1957.

549. Chu, B. T., Wave propagation and the method of characteristics in reacting gas mixtures with applications to hypersonic flow, *WADC TN* 57–213, 48 pp., May 1957.

The development of this theory is made general enough to apply to flows with combustion as well as to extremely high-speed flows

where dissociation and allied phenomena are present. After presenting a resumé of chemical reaction kinetics, the equations of motion for an inviscid reacting gas mixture are given. The characteristic equations are then derived and discussed in terms of equilibrium flow, "frozen" or slow reacting flow, and flows with high but finite reaction speeds. The characteristic surfaces are found to propagate at a sound speed given by

$$a[\partial/\partial_\rho p(\rho, S, \gamma_1 \ldots . \gamma_n)]^{1/2}$$

where the gas-mixture-composition mass ratios γ_i as well as entropy are held constant in the differentiation. This differs from a well-known result for equilibrium sound speed

$$a_e = \{(\partial/\partial_\rho)\, p[\rho, S, \gamma_{1e}(\rho, S), .. \gamma_{ne}(\rho, S)]\}^{1/2}$$

in which only entropy is held constant in the differentiation. An analysis of two simplified problems in one-dimensional, near-equilibrium flow shows that the wave front travels at the speed given by a, while the bulk of the fluid properties are propagated at the speed a_e. The quantity a is called the wave-front velocity and a_e is called the phase velocity. A method of characteristics applicable to a reacting gas mixture is briefly outlined.

F. M. Hamaker, USA

550. Bloom, M. H., and Pallone, A., Heat transfer to surfaces in the neighborhood of protuberances in hypersonic flow, Heat Trans. and Fluid Mech. Inst., Calif. Inst. Technol., Pasadena, Calif., June 1957, 249–278.

An investigation of surface temperature on the wall of a blow-down tunnel in the neighborhood of insulated protuberances of three designs. The tunnel was operated at Mach 6 with a stagnation pressure of 600 psia and stagnation temperature of 1460 to 1600 R, with surface temperatures always below 630 R. The metal protuberances were mounted in, and insulated from, the free wall with asbestos and consisted of: 3/8-in. diameter perpendicular to wall of 2-in., 1-in., 3/4-in., and 1/2-in. length, 1-in. diameter perpendicular to wall 2-in. and 1-in. long, and 3/8-in. diameter mounted with axis 45° to wall, truncated parallel to wall, 1 in. from wall, and mounted either pointing upstream or downstream. Authors estimated boundary-layer thickness as 1.4 inches. Surface temperatures were measured during blow-down, at 19 points near the protuberance, using thermocouple gages and the resulting temperature-time curve was used to calculate heat flux at each point. Only large effects were reported and discussed qualitatively. Heating rate was found to be 2–4 times undisturbed value for upright cylinders, somewhat less for sweptback, and 4–5 times undisturbed rate for sweptforward cylinders. No correlation of heating rates could be made for the different size upright cylinders on the basis of simple geometric similarity. Boundary-layer properties and average protuberance temperatures were measured.

R. A. Strehlow, USA

551. Charwat, A. F., The stability of bodies of revolution at very high Mach numbers, *Jet Propulsion* **27,** 8 (part 1), 866–871, Aug. 1957.

The Newtonian theory is used to study the stability of bodies of revolution at high hypersonic velocities such as may be encountered in the flight of satellites or the re-entry of high-altitude missiles. The important stability criteria are brought out and the allowable approximations are studied. Several numerical examples are worked out. It is observed that configurations with cylindrical afterbodies exhibit two possible equilibrium trajectories. One is a vertical drive and the second is a glide at an angle uniquely determined by the location of the center of gravity. The latter is the only completely stable trajectory. This is brought about by the characteristic of the Newtonian wake and it can be eliminated by using a truncated cone instead of a cylinder for the afterbody. The importance of the drag force in determining the stability of bluff bodies is shown.

From author's summary by T. Gullstrand, Sweden

552. Isakson, G., A simple model study of transient temperature and thermal stress distribution due to aerodynamic heating, *J. aero. Sci.* **24,** 8, 611–619, Aug. 1957.

The present work is concerned with the determination of transient temperatures and thermal stresses in simple models intended to simulate parts or whole of an aircraft structure of the built-up variety subjected to aerodynamic heating.

The first case considered is that of convective heat transfer into one side of a flat plate, representing a thick skin, and the effect of the resulting temperature distribution in inducing thermal stresses associated with bending restraint at the plate edges. Numerical results are presented for the transient temperature differentials in the plate when the environment temperature first increases linearly with time and then remains constant, the period of linear increase representing the time of acceleration of the aircraft. Corresponding thermal stress information is presented.

The second case is that of the wide-flanged I-beam with convective heat transfer into the outer faces of the flanges. Numerical results are presented for transient temperature differentials for a wide range of values of the applicable parameters and for an environment temperature variation as described above. Corresponding thermal stresses in a beam of infinite length are determined. A theoretical analysis of the stress distribution in a beam of finite length is carried out and numerical results are presented for one case. An experimental investigation of temperatures and stresses in such a beam is described, and results are presented which indicate good agreement with corresponding theoretical results.

From author's summary by D. H. Cheng, USA

553. Hawthorne, W. R., Some aerodynamic problems of aircraft engines, *J. aero. Sci.* **24,** 10, 713–730, Oct. 1957.

A fascinating and authoritative account of the development of the gasdynamics of jet engines, including an historical survey of the treatment of compressibility effects in fluid dynamics; the complications brought about by friction; the intricacies of axial compressors with special consideration of three-dimensional and secondary flow aspects as well as the phenomenon of propagating stall; the problems of combustion; the analysis of flow with heat addition; and some remarks on thrust, pointing out its intimate relation with drag.

A. K. Oppenheim, USA

554. Moretti, G., On the calculation of convergent canals (in Italian), *Comun. Inform. Esceula super. Aerotecn. Cordoba* C-10, 19 pp., Nov. 1954.

Wave Motion in Fluids

(See also Revs. 400, 512, 700)

555. Evans, C., and Evans, F., Shock compression of a perfect gas, *J. fluid Mech.* **1,** 4, 399–408, Oct. 1956.

Authors develop simple expressions for the thermodynamic properties and shock kinematics of a perfect gas which is compressed in a closed tube by a uniformly moving piston. Formulas for density, pressure, temperature, and entropy after any number of shock reflections are expressed in Γ functions. The limiting ratios, as the number of reflections goes to infinity, of these properties to corresponding properties for reversible adiabatic compression are determined for various initial shock strengths and specific heat ratios. Numerical examples show that most of the deviations from reversible adiabatic compression occur across the first shock for very strong shocks and that in many cases these limiting values are rapidly approached after only a few shock reflections.

J. S. Holdhusen, USA

556. Crapper, G. D., An exact solution for progressive capillary wave of arbitrary amplitude, *J. fluid Mech.* **2,** 6, 532–540, Aug. 1957.

Author finds an exact solution for two-dimensional progressive waves of arbitrary amplitude, for the case when surface tension provides the only significant restoring force. The method is to transform the equations of motion into the (φ, ψ)-plane (φ being the velocity potential, and ψ the stream function) and then to use separation of variables. The solution yields the effect of wave amplitude on wave velocity, and several other interesting results. The wave of greatest height is found to occur when the vertical distance between trough and crest is 0.730 wave lengths.

No experimental evidence supporting the conclusions is offered, but the paper is a useful contribution to theoretical fluid mechanics. L. C. Woods, Australia

557. Grigorash, Z. K., The experimental investigation of the solitary wave in a channel of varying cross section (in Russian), *Trudi Mor. gidrofiz. in-ta Akad. Nauk SSSR* **5,** 53–58, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5941.

The study is dedicated to the experimental checking of the applicability of the formulas of Erie-Green, Boussinesq and Scott-Russell for the investigation of the solitary wave in a channel of varying depth. In the case where the depth of water in the channel is constant, the conclusions of Scott-Russell and Boussinesq agree well with the observations. If the depth of the channel changes linearly, then marked divergence between the precalculated and the observed is possible:

(1) The height of the solitary wave increases with the decrease in depth and markedly exceeds (up to 20%) the value for height calculated by the Erie-Green formula.

(2) With one and the same impulse, a higher wave is obtained in the deeper part of the water-basin.

(3) The speed of the solitary wave shows no apparent change with change in the depth of water and differs from the speed calculated by Boussinesq by 8% (approximately) and Scott-Russell by 30% (approximately). N. N. Moiseev, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

558. Gyul', K. K., Theory and practice in determining the size of the largest wave (in Russian), *Ucb. Azerb. un-ta* no. 4, 21–36, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5939.

Author says that an understanding of the size of the largest wave appears to be undetermined and depends on requirements of a concrete engineering specification (for instance, the maximum size of a wave permissible in the design of a hydro-installation). On the basis of the investigational materials, author concludes that the five-minute period for observation recommended by GUMS appears to be insufficient, and that it would be more correct if the "largest wave" were determined from the records of wave-measuring instruments, or by the maxiumm rules, but for a longer period of time; this applies also to cases of visual observations.
Courtesy Referativnyi Zhurnal A. M. Ter-Krikorov, USSR
Translation, courtesy Ministry of Supply, England

559. Campbell, I. D., The transmission of a plane wave between parallel plates, *Acustica* **5,** 6, 298–302, 1955.

The transmission of a plane wave between infinite parallel plates is discussed theoretically, allowance being made for the effects of viscosity and thermal conduction. The use of an approximate method allows the attenuation and phase velocity to be deduced at all frequencies. Some experimental measurements are presented for comparison with the theory.
From author's summary

Turbulence, Boundary Layer, etc.

(See also Revs. 519, 585, 598, 617, 626, 631, 642, 651, 669, 693, 703)

560. Timman, R., Zaat, J. A., and Burgerhout, T. J., Stability diagrams for laminar boundary-layer flow, *Nat. LuchtLab. Amsterdam TN* F. 193, 11 pp. + 11 figs., 1956.

Paper gives the stability characteristics of a one-parameter family of velocity profiles formerly used by Timman for calculations of the development of the boundary layer, the parameter being equivalent to a Pohlhausen parameter. The velocity profile for the case of zero Pohlhausen parameter is very close to the Blasius flow, and the results on the stability characteristics are also in close agreement with those obtained by Lin, but differ somewhat from those obtained by Schlichting. C. C. Lin, USA

561. Zaat, J. A., A simplified method for the calculation of three-dimensional laminar boundary layers, *Nat. LuchtLab. Amsterdam Rap.* F. 184, 13 pp., Apr. 1956.

This is a method based on an earlier one due to Timman [AMR **4,** Rev. 3009], with a considerable simplification, because of author's assumption of semi-independence, namely that the boundary-layer velocities in a direction perpendicular to the local external flow are small compared with those parallel to it.

Author has thereby produced what is perhaps the first really practical method of calculating general three-dimensional boundary layers; considering the complexities of the problem, the computational effort required is not at all excessive.

Method is based on momentum equations, as nearly all approximate methods are; equations of flow along the streamlines reduce to a quadrature. The crossflow equation is not so simple, but labor required is by no means excessive. Author has tested the method on an ellipsoid, already calculated by Timman's full method. Agreement is very good.

Author applies his method to an infinite yawed cylinder, to two-dimensional flow, and to axially symmetric flow. The last two reduce to the well-known results of Thwaites and Truckenbrodt.

Two main questions remain: (1) Is Timman's original method, a momentum equation method, on which this one is based, satisfactory? (2) In what cases can the semi-independence principle, on which the simplification depends, be relied upon? Answers to these questions depend on some exact results being found.
J. C. Cooke, England

562. Geis, T., Similar solutions in unstationary laminar boundary layer flow (in German), *ZAMM* **36,** 9/10, 396–398, Sept./Oct. 1956.

H. Schuh in a previous paper ["50 Jahre Grenzschichtforschung," ed. by H. Görtler and H. Tollmien, p. 147–152, 1955] found four cases of similar solutions of the unsteady laminar boundary-layer equations in incompressible flow. In deriving these it was assumed that certain coefficients (four in number) were constant. Author investigates cases where these coefficients are functions of coordinate in mean flow direction and of time. He finds one new solution and proves that this and Schuh's previous solutions exhaust the possibilities of further similar solutions.
H. Schuh, Sweden

563. Hammitt, A. G., An analysis of the interaction of shock waves with unseparated turbulent boundary layers, Princeton Univ., Dept. of Aero. Engng. Rep. 371, iv + 15 pp. + 9 figs., Feb. 1957.

Author shows that interaction between shock wave and turbulent boundary layer can be studied by assuming that the pressure rise inside the layer is discontinuous (i.e., shock penetrates deep into the boundary layer), provided the strength of shock is not sufficient

to cause separation. The analysis is essentially a modified shock-wave theory, valid for both inside and outside of the boundary layer. To take care of the transport phenomena inside the viscous layer, integrated boundary-layer properties are used. The two parameters (a form factor and a thickness measure parameter) used for representing the average boundary-layer properties were originally suggested by Crocco; they enable the continuity and momentum equations to be satisfied for any boundary-layer thickness. The shock-wave equations so developed reduce to ordinary free-stream shock relations when these parameters take on the value unity.

The wall pressure measurements seem to justify this assumption of discontinuous pressure rise inside boundary layer for weak incident shock. The predicted wave patterns are confirmed by schlieren photographs, both for normal and oblique incident shocks.

H. S. Tan, USA

564. Mager, A., Transformation of the compressible turbulent boundary layer, Heat Trans. and Fluid Mech. Inst., Calif. Inst. Technol., Pasadena, Calif., June 1957, 85–98.

It is shown that Young's equation of the steady compressible turbulent boundary layer may be transformed into an incompressible equivalent in a similar way to the Illingworth-Stewartson transformation for laminar boundary layers. In order to do this the additional assumption is made that the apparent turbulent shear per elemental mass is invariant. Author is then able to use the properties of incompressible turbulent boundary layers to determine the effect of compressibility on skin friction and on the pressure rise at separation. Good agreement is obtained with experiment.

K. Stewartson, England

565. Wilbur, S. W., and Higginbotham, J. T., Investigation of a short-annular-diffuser configuration utilizing suction as a means of boundary-layer control, *NACA TN* 3996, 33 pp., June 1957.

In a duct with annular section, the center body had an end of ellipsoidal form, so that the section increases very rapidly and forms a diffusor, the length of which is shorter than the diameter of the outer wall. In this part of the inner wall the boundary layer was sucked away. The quantity of air sucked away from the boundary layer was varied as well as the shape, number and location of the openings, through which the air was removed. The inlet flow was parallel to the axis or was rotational with 19.5° inclination to the axis. The diffusor effectiveness and the velocity distribution behind the diffusor were investigated.

A. Betz, Germany

566. Sternberg, J., The transition from a turbulent to a laminar boundary layer, *Aberdeen Prov. Ground, BRL Rep.* 906, 110 pp., May 1954.

The boundary layer on a 58° included angle cone-cylinder model has been studied over a range of supersonic speeds. Boundary-layer recovery factors have been measured and shadowgraphs have been taken of the model in the wind tunnel and free flight. These measurements indicate that when the boundary layer ahead of the shoulder is turbulent, the boundary layer is laminar after the shoulder for a short distance. A theoretical model of the phenomenon has been constructed and calculations have been made using available boundary-layer theory and experimental data to describe the course of the boundary layer from just ahead of the shoulder to the transition back to turbulent flow on the cylinder. Reasonably good agreement is found between the experiments and the calculations.

A distinction is made between the complete shear layer at a given position which results from the action of frictional forces all along the model surface from the model tip, and the boundary layer at the same position which may be all or only the inner portion of the complete shear layer.

A turbulence parameter analogous to Taylor's turbulence parameter for the effect of a turbulent free stream on laminar turbulent transition, but applicable to a high-speed boundary layer, is obtained.

From author's summary

567. Gadd, G. E., The effects of convex surface curvature on boundary layer separation in supersonic flow, *Aero. Res. Counc. Lond. curr. Pap.* 289, 6 pp. + 18 figs., 1956.

The effects of convex surface curvature on boundary-layer separation in supersonic flow have been investigated experimentally and theoretically. The radius of curvature used in the experiments was about 3 times the distance from the leading edge of the surface on which the boundary layer was formed to the separation point. In accordance with theory, the surface curvature greatly reduced the separation pressure coefficient for laminar layers, but for turbulent layers (for which no theory of the effects of curvature has yet been developed) there was little effect.

From author's summary

568. Hama, F. R., Long, J. D., and Hegarty, J. C., On transition from laminar to turbulent flow, *J. appl. Phys.* **28,** 4, 388–394, Apr. 1957.

Water-tank observations of the flow phenomena associated with boundary-layer transition have revealed that a two-dimensional discrete vortex line, which is considered to be the consequence of an amplified perturbation wave, has a strong tendency, in shear flows, to form three-dimensional vortex loops with a marked transverse wave length. The formation and development of the vortex loop is found to be the essential feature preceding the creation of a turbulent spot which takes place near the top of the vortex loop and near the outer edge of the boundary layer. This formation and development provides the guiding principle of laminar-to-turbulent transition in wakes and jets as well as in the boundary layer.

From authors' summary

569. Dannenberg, R. E., Weiberg, J. A., and Gambucci, B. J., Perforated sheets as the porous material for a suction-flap application, *NACA TN* 4038, 36 pp., May 1957.

Report gives an account of experiments carried out with a two-dimensional model of an NACA 0006 airfoil with area suction applied on the upper surface near the hinge line of a 0.3-chord plain trailing-edge flap. The distribution of the suction quantity taken into the porous region was controlled generally by means of perforated metal sheets. The permeability of the sheets was controlled by the size and the spacing of the holes. A wide variety of hole sizes and perforation patterns was tested with uniform and gradient arrangements of permeability.

Measurements were made of both the pressure and the suction velocity distributions over the surface of the porous region for each permeability arrangement tested for a range of suction flow extending from no flow to a value well above that required for separation control over the flap. Further information on the effects of hole size and spacing was provided by use of perforated sheets with a resistance backing to control the inflow distribution. Limits are indicated for the hole size and the hole spacing suitable for the porous region on a suction flap.

From authors' summary

570. Gadd, G. E., and Holder, D. W., Boundary layer separation in two-dimensional supersonic flow, *Aero. Res. Counc. Lond. curr. Pap.* 270, 8 pp. + 12 figs., 1956.

571. Tetervin, N., Remarks concerning transition Reynolds numbers on cones and flat plates, *J. aero. Sci.* **24,** 7, 545–546, July 1957.

572. Stalker, R. J., The pressure rise at shock-induced turbulent boundary-layer separation in three-dimensional supersonic flow, *J. aero. Sci.* **24,** 7, p. 547, July 1957.

573. Szablewski, W., Turbulent mixing of two-dimensional hot air jets (in German), *Ing.-Arch.* **25,** 1, 10–25, 1957.

Author extends previous theory [AMR **6,** Rev. 980] to cases with large velocity differences between the adjacent streams. Problem is limited to region near jet nozzle by assumption of infinite free streams each side of the mixing plane. Solution requires iterative numerical integration; resulting curves are shown for initial velocity differences of 25, 50, 75, and 100% of the jet velocity, and initial temperature differences of 0, 1, 2, and 5 times the absolute temperature of the secondary flow. Curves compare favorably with data of O. Pabst [U.u.M. 8004, 1944].

Author shows how his equations differ fundamentally from those of Pai [AMR **3,** Rev. 2707], but does not compare the results directly. Author's equations include terms involving density fluctuations and their cross correlation with velocity fluctuations. They also include allowance for a "turbulent Prandtl number." However, Pai's solution allows eddy diffusivity to vary as x^n, while present author's treatment assumes $n = 1$.

Reviewer feels treatment can aid in design. Further study of the fundamental problem requires more detailed study of the nature of the shear turbulence itself. R. R. Hughes, USA

574. Bakke, P., An experimental investigation of a wall jet, *J. fluid Mech.* **2,** 5, 467–472, July 1957.

Paper deals with an experimental investigation of a turbulent low-speed jet of air spreading out radially over a flat smooth plate. The aim of the experiments has been to determine the mean velocity distribution and rate of growth of the jet. It is found, within the experimental range and accuracy, that the velocity profiles are similar and that the rate of change of velocity and width of the jet can be expressed by simple power laws. M. S. Uberoi, USA

575. Timme, A., Velocity distributions in vortexes (in German) *Ing.-Arch.* **25,** 3, 205–226, 1957.

Author reports on his experimental results in measuring velocity distributions in Kármán vortex streets. The measurement was carried out by photographing the marked surface of the flow. With the Hamel-Oseen velocity law, the kinematic viscosity and the circulation are calculated. The results are discussed theoretically.
R. Albrecht, Germany

Aerodynamics of Flight; Wind Forces

(See also Revs. 530, 533, 536, 537, 542, 545, 590, 591, 596, 605, 609, 619)

576. Finn, R., and Gilbarg, D., Asymptotic behavior and uniqueness of plane subsonic flows, *Comm. pure appl. Math.* **10,** 1, 23–63, Feb. 1957.

Paper establishes asymptotic properties of subsonic flows defined in a neighborhood of infinity. These results are used for the derivation of the force and moment formulas of gas dynamics, for the proof of uniqueness of subsonic flows past a profile, and for the determination of the complete expansion of a subsonic flow at infinity. The asymptotic properties of solutions of the flow equation appear as a special case of more general results concerning nonlinear elliptic equations, and are presented in this context.

It is the author's intention to apply these methods to three-dimensional flow in a later work. T. Gullstrand, Sweden

577. Weber, J., Kirby, D. A., and Kettle, D. J., An extension of Multhopp's method of calculating the spanwise loading of wing-fuselage combinations, *Aero. Res. Counc. Lond. Rep. Mem.* 2872, 24 pp., 1956.

Multhopp ["Aerodynamics of the fuselage," *Luftfahrtforschung* **18,** p. 52, Mar. 1941. RTP Translation no. 1220. Aero. Res. Counc. 5263] related the boundary conditions in the Trefftz plane to those on the wing and body, and also introduced a transformation of the Trefftz plane which simplifies the calculation of the flow field.

This extension of Multhopp's method takes into account wing thickness, sweep back, and the ratio of wing chord to body diameter. Comparison with the original method and with experiment shows that some improvement is made in the loading distribution calculated for swept wings. L. H. Schindel, USA

578. Jungclaus, G., Pressure distribution of known profile types in incompressible flow (in German), *Z. Flugwiss.* **5,** 4, 106–114, Apr. 1957.

F. Riegel's method for the calculation of velocity distributions around two-dimensional airfoils in incompressible flow [*Ing.-Arch.* **16,** 373–376, 1948; **17,** 94–106, 1949; **18,** p. 329, 1950] contains two approximations: (1) the function mapping the airfoil section onto the circle is expanded with respect to thickness; (2) the integrals which appear are calculated by mechanical quadratures. Paper treats some cases for which these integrals can be evaluated analytically. For the plane plate with kink, for the contours of the NACA profile series with four and five digits, and for an NACA thickness distribution, explicit analytical expressions for the pressure at the airfoil are given. Some special cases are calculated numerically and compared with known results.

The method given can be used for all profiles with contours and thickness distributions which are piecewise defined by polynomials in x and $\sqrt{x}$ (x distance from the leading edge), a finite number of jumps in the first or higher derivatives being admitted.
H. Behrbohm, Sweden

579. Frenzl, O., Nacelle-wing interference at high speeds (the area rule) (in German), *Z. Flugwiss.* **5,** 6, 181–183, June 1957.

Paper reports on investigations made at Junkers Flugzeug- und Motorenwerke in 1943. These investigations formed the basis for an invention on low drag design of high-speed aircraft (German Patent no. 932410 of the year 1944). An area rule has been formulated according to which all bodies outside the aircraft contour should be arranged with respect to their shapes and positions in such a way that the sum of their cross-sectional area in flight direction increases monotonically up to a maximum and than decreases again monotonically, whereby sudden changes should be avoided. It reveals that part of the knowledge which resulted from the work of Whitkomb and Keune-Oswatitsch and other authors was already known, at that time.
J. Rotta, Germany

580. Sillion, E., Research on definitions and on criteria of nonoscillatory divergence in the neighborhood of a steady flight domain (in French), *ONERA NT* 38, 57 pp., 1956.

Author uses the term nonoscillatory convergence instead of static stability and nonoscillatory divergence instead of static instability. He derives the explicit expressions for the absolute term of the characteristic equations for the longitudinal and the lateral mode of disturbances of straight and helical flights. He develops a transformation theory which allows representing the absolute term by expressions as closely related as possible to magnitudes measurable in a wind-tunnel.
G. W. Braun, USA

581. Eggleston, J. M., A theory for the lateral response of airplanes to random atmospheric turbulence, *NACA TN* 3954, 75 pp., May 1957.

Paper estimates the statistical relations between gust velocities and the resulting forces and moments which are needed to compute the lateral airplane motion. Thus the new theory includes the intermediate step of statistically estimating directly the forces and moments as against the earlier method of using effective

forces and moments to produce the aircraft motions. The method takes into account the random variations of gust velocities across the span and along the fuselage. It is illustrated on three aircraft with wing areas in the approximate ratio 1:2:6 and trimmed at low angle of attack. It is found in these cases that gust-produced side forces and gust parallel to the flight path have negligible effect on the aircraft motion. The new theory is compared to previous theories on the basis of gust distributions required to produce equivalent aircraft motions and also for aircraft motions resulting from the same assumed gust characteristics.

M. G. Scherberg, USA

582. Klawans, B. B., and White, J. A., A method utilizing data on the spiral, roll-subsidence, and Dutch roll modes for determining lateral stability derivatives from flight measurements, *NACA TN* 4066, 26 pp. + 2 tables + 10 figs., Aug. 1957.

Authors discuss problem of evaluating the coefficients of the aircraft lateral stability equations if the solutions to these equations are known. The stability equations are rewritten in convenient form, and the task of solving for certain coefficients (the lateral stability derivatives) is accomplished in a straightforward manner. The method consists of substituting the known roots into the stability equations. The satisfaction of the differential equations requires a number of identities to be satisfied, and these identities are the conditions which enable one to solve for the unknown stability derivatives. The problem is always overdetermined for systems of more than one degree of freedom, and this fact enables the analyst to make an arithmetically "best" choice among several possible procedures. A numerical example is given.

This report would have been of more value if it had been written in terms of more general sets of equations, but it does represent a novel effort in the field of aircraft stability analysis.

F. W. Niedenfuhr, USA

583. Welch, J. D., and Wilson, R. E., Cross-coupling dynamics and the problems of automatic control in rapid rolls, *J. aero. Sci.* **24,** 10, 741–754, Oct. 1957.

Some of the fundamental properties of inertial cross coupling are reviewed, with special emphasis on the inertia coupling terms which may cause apparently similar aircraft to exhibit different characteristics. Typical time histories of all the components of aircraft accelerations are presented to give a detailed insight into the dynamics resulting from inertial cross coupling.

The problems of automatic control in minimizing objectionable characteristics during rapid rolls are discussed. A simplified method for analyzing the control problem is presented as well as a discussion of the practical problems, such as measurement techniques, reliability, and fail-safe considerations.

From authors' summary by H. P. Liepman, USA

584. Arthur, P. D., and McJones, R. W., Effective lift drag ratio with jet lift, *Jet Propulsion* **27,** 6, 676–677, June 1957.

585. Heath-Smith, J. R., Turbulence encountered by Viking aircraft over Europe, *Aero. Res. Counc. Lond. curr. Pap.* 311, 6 pp. + 4 tables + 4 figs., 1957.

586. Scott, R. P. W., and Cheshire, J. D., Aerodynamic drag of perforated plates, *Nature* **180,** 4588, 702–703, Oct. 5, 1957.

Aeroelasticity (Flutter, Divergence, etc.)

587. Gillies, D. B., and Hunt, P. M., A solution of the flutter determinant on a general purpose electronic digital computer, *Aero. Quart.* **8,** 2, 185–203, May 1957.

Solution of flutter problem with n degrees of freedom is discussed. Generalized aerodynamic forces are written in terms of generalized displacements and velocities by means of aerodynamic stiffness and damping coefficients. Problem then becomes one of investigating the roots of the associated stability polynomial of degree $2n$. Coefficients of this polynomial are found by evaluating flutter determinant at $2n + 1$ (real) points and then using Lagrange's interpolation formula. Optimum choice of point location and errors arising from procedure are analyzed. Details of the program for the N.R.D.C. 401 computer are given. Computer time for each velocity for a four-degree-of-freedom problem is slightly less than two minutes.

J. M. Hedgepeth, USA

588. Garner, H. C., Multhopp's subsonic lifting-surface theory of wings in slow pitching oscillations, *Aero. Res. Counc. Lond. Rep. Mem.* 2885, 49 pp., 1956.

Since the forces on a wing oscillating in pitch depend inherently on the chordwise loading, "lifting-line" methods of computing load distribution cannot be employed. The lifting-surface method of Multhopp [see AMR **11,** Rev. 533] has therefore been modified to permit calculation of the first-order effects of pitch frequency. The modification results in the tabulation of two new influence functions to account for the changed boundary conditions; otherwise the procedure is similar to that for steady wings. Numerical results are presented for some circular, arrowhead, and delta wings. Comparisons are made with experiment and with other theories.

L. H. Schindel, USA

589. Rogallo, V. L., Yaggy, P. F., and McCloud, J. L., III, An analysis of once-per-revolution oscillating aerodynamic thrust loads on single-rotation propellers on tractor airplanes at zero yaw, *NACA Rep.* 1295, 30 pp., 1956.

Bending stresses in propeller blades resulting from periodically varying thrust have long been recognized as possible cause of fatigue failure. Most dangerous excitation has usually been an oscillating blade normal force (sum of components of thrust and torque forces perpendicular to blade chord) which completes one cycle during one revolution of propeller. Conventional treatment has been to make experimental survey to determine flow-field values needed to calculate forces—a slow and costly process. This paper proposes simplified method requiring knowledge only of upflow angles at horizontal center line of propeller disk and gives approximate method of calculating these angles. Simplification comes in large part from observation that odd-order harmonics do not occur in particular cases of vibration investigated. Comparison of results with those obtained by conventional methods shows mostly satisfactory agreement.

C. W. Smith, USA

590. Woodcock, D. L., Aerodynamic derivatives for two cropped delta wings and one arrowhead wing oscillating in distortion modes, *Aero. Res. Counc. Lond. curr. Pap.* 268, 69 pp., 1956.

Aerodynamic derivatives are given for three particular planforms oscillating with symmetric distortion modes in incompressible flow. The planforms are:

(1) a cropped delta wing of aspect ratio 3 and taper ratio 1/7;

(2) a cropped delta wing of aspect ratio 1.2 and taper ratio 1/7;

(3) an arrowhead wing of aspect ratio 1.32, taper ratio 7/18, and angle of sweep of 63.4° at the quarter chord.

The results are for modes of the form $|\eta|^n$ for $n = 0(1)4$ where η is a nondimensional spanwise coordinate. They have been determined from intermediate results which D. E. Lehrian had earlier obtained by the vortex lattice method. The results are compared, for some cases, with the corresponding values given by very low aspect ratio theory.

From author's summary

591. Hall, H., Flutter calculations on a resonance model delta wing, *Aero. Res. Counc. Lond. curr. Pap.* 260, 10 pp. + 5 figs., 1956.

Resonance tests on a dural model delta wing are used as a basis for flutter calculations to determine the effect on the flutter characteristics of changes in structural inertias and stiffnesses. Forward movement of the inertia axis and increased stiffness of the wing spars are shown to be separately beneficial.

The calculated flutter speeds are compared with flutter speeds given by formulas derived from earlier flutter tests on model delta wings in the wind tunnel and on ground-launched rockets. There is qualitative agreement on the effects of the structural changes, but the absolute values of flutter speed differ appreciably. Possible explanations for the differences are discussed.

From author's summary

592. Wolfe, M. O. W., Vibration and flutter flight testing, *Aero. Res. Counc. Lond. curr. Pap.* 310, 12 pp. + 8 figs., 1956.

A review is made of the techniques that have been developed or are being developed in the United Kingdom for flight vibration testing and flight flutter testing aircraft. This includes a description of the instrumentation used for recording the vibrational response, and a comparative assessment of the various methods used for exciting the aircraft in flight flutter tests.

From author's summary

593. Kilpatrick, D. A., and Ritchie, J., Compressor cascade flutter tests—Part II. 40° camber blades, low and medium stagger cascades, *Aero. Res. Counc. Lond. curr. Pap.* 296, 9 pp. + 10 figs., 1956.

594. Niblett, L. T., Flutter calculations on a supersonic aircraft wing, *Aero. Res. Counc. Lond. curr. Pap.* 328, 9 pp. + 6 figs., 1957.

Flutter calculations have been made on a straight-tapered unswept wing of low-aspect-ratio both with and without wing engines to discover the stiffness necessary to avoid flutter up to a Mach number of 2, and to find whether wing engines can be used to massbalance the wing effectively. Simple arbitrary modes of flexure and torsion were assumed and calculations were made using subsonic, transonic, and supersonic derivatives.

It has been found that the stiffness required to prevent flutter of the bare wing is not excessive and that wing engines have a powerful massbalancing effect if placed forward on the wing. The transonic case is the most critical, but as the transonic derivatives used were two-dimensional this conclusion must be regarded as tentative. From author's summary

595. Garner, H. C., and Acum, W. E. A., Problems in computation of aerodynamic loading on oscillating lifting surfaces, *Aero. Res. Counc. curr. Pap.* 309, 15 pp., 1957.

Authors give a careful and critical summary of various linearized theories of oscillating wings in subsonic and supersonic flow. In the case of subsonic flow they include the relatively simple integral equation of W. P. Jones, and the modified kernels introduced by Watkins, Runyan, Woolston and Lance. Special attention is paid to the computability of the subsonic problem when Mach number, frequency, and aspect ratio are arbitrary. Methods of treating aerodynamic flutter problems are briefly outlined. Paper concludes with recommendations for computation of the general subsonic problem for a rectangular wing and for the development of special theories specially suited to high-speed computation.

G. Temple, England

596. Timman, R., and van de Vooren, A. I., Flutter of a helicopter rotor rotating in its own wake, *J. aero. Sci.* **24,** 9, 694–702, Sept. 1957.

Paper gives a simplified treatment of the unsteady flow field of a rotor which is rotating in still air (i.e. no flow through the rotor plane), taking into account the accumulation of vortices in the wake of each blade. Two-dimensional flow is assumed. When mutual interference of the blades is neglected, the aerodynamic forces can be found as for a single oscillating airfoil, provided a modified circulation function is used. (This is in agreement with AMR **10,** Rev. 2224, which also deals with case of low inflow through the rotor.)

Theory is used to investigate blade flapping-pitching flutter which occurred on a two-bladed rotor having a relatively weak elastic connection between each blade and the rotor hub. While classical flutter theory could predict certain instabilities, the above theory using vortex accumulation was able to predict the wake flutter experienced in practice, including the effect of varying the inertia axis. Wake flutter can be eliminated by complete static balance of the blades. A small air speed perpendicular or parallel to the rotor plane was sufficient to prevent wake flutter. Thus this type of flutter would only cause practical difficulties on the ground or in autorotation.

At low Reynolds numbers (about 32,000), single-degree-of-freedom flutter can occur due to movement of transition point in an oscillatory motion. However, this is only of importance for models. A. W. Babister, Scotland

597. Blunden, W. R., Hooke, F. H., Messerle, H. K., A study of aircraft response to sudden and graded wind gusts by means of a differential analyser, *J. appl. Phys.* **28,** 4, 167–173, Apr. 1957.

Authors adapt the problem of determination of response of an aircraft to a known wind gust to the numerical solution by an electromechanical differential analyzer. Assuming sharp-edged or graded wind gusts, and approximating the aerodynamic functions $k_1(s)$ and $k_2(s)$ by sums of exponential functions, the problem is transformed into a set of total differential equations which can be solved by the differential analyzer for any given aircraft parameters such as mass and flexibility. Several numerical solutions are given. An average solution took 15–20 min to run. Authors claim an accuracy better than 1% of full-scale values for a flexible aircraft.

H. Schlichting, Germany

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 486, 489, 511, 515, 529, 551, 553, 589, 593, 633, 638, 649, 679, 724)

598. Kaye, J., and Rivas, M. A., Jr., Experimental and analytical study of two-component two-phase flow in an ejector with condensation, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-35, 17 pp.

The special case of the behavior of ejectors when using two different fluids, in both liquid and vapor phase, for driving and induced flows is considered. The problem of pressure recovery in the mixing section is first examined theoretically, and the formation of a normal shock, as in single-component, single-phase ejectors, is postulated. Confirmatory experimental tests using air, steam, and water were made; the predicted and measured values agree within 10% for design point operation and 20–30% for "off-design" operation.

G. C. Quigg, Australia

599. Winter, H., Use of rotor with axial acceleration as initial stage of multistage axial compressor (in German), *Jahrbuch Wissenschaft. Gesellsch. Luftfahrt,* 51–54, 1956.

Design is proposed to increase average pressure ratio per stage so that number of stages required for given over-all pressure ratio may be reduced. By insertion of entry stage with greater area on entrance side than on exit side, flow is accelerated in axial direction; velocity diagrams show this can result in increased pressure ratio. Only test results have been obtained with parts not designed particularly for this purpose, but author believes results show promise.

Reviewer believes method is of interest to compressor designers and should be understood and evaluated by them. He wishes to point out, however, that other proposed designs along somewhat similar lines have not been successful in practice, or only partly so, probably because they have so changed the relation of stage pressure ratio to flow (a basic parameter determining the general level of performance attainable) that any gain from the effect here considered was more than neutralized. This can also be the reason why such methods sometimes give gain with one compressor but not with another of different (usually lesser) capacity.

C. W. Smith, USA

600. Leonkov, A. N., A record of some results of trials with a revolving model of a turbine stage (in Russian), *Trudi Bezbitsk. in-ta transp. masbino-str.* no. 15, 51–53, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5861.

Data are given for tests on a model of a revolving turbine stage of the operative type. The investigations were made in the axial space. Determinations were made of the value of statistical and full compression, the angles of exit, the axial and circumferential velocity components. It was shown that for the active stage, when $u/c_0 = 0.46$ at the base of the blades, a negative degree of reaction equalling 15° is encountered (here u = the circumferential speed; c_0 the conventional speed, corresponding to the distribution of ten drops in heat over the whole stage; d diameter of the stage, l = the height of the blade); at the periphery of the blades the degree of reaction equals 14%. In the region of overlap the output of the working center rarely diminishes.

M. I. Zhukovskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

Book—601. Markov, N. H., The calculation of the aerodynamic characteristics of the blade arrangement of a turbomachine (in Russian), Moscow-Leningrad. Mashgiz, 1955, 163 pp. 4r, 85k; *Ref. Zh. Mekh.* 1956, Rev. 5854.

The monograph is dedicated to the evaluation of three-dimensional flows at low subsonic speeds in the cascades of steam and gas turbines. The following matters are investigated: a calculation of profile losses in a two-dimensional cascade with nonterminal fire exit vents [*Sudostroenie*, no. 4, 1947]; an empirical evaluation of end-losses; a calculation of the parameters of the flow in front of and behind the working cascades and the characteristics of the axial turbine emanating from the given characteristics of two-dimensional cascades and the hypothesis of cylindrical sections [*Ref. Zh. Mekh*, 1955, Rev. 4225]; a method of calculating the three-dimensional boundary layer of an incompressible liquid on the front wall and on the revolving blade [*Dokladi Akad. Nauk SSSR* **71**, no. 2, 1950; **73**, no. 1, 1950].

Examples of calculations are given of the characteristics of a two-dimensional lattice and the stage of a turbine, and also numerous experimental data.

The method developed by the author for the calculation of the three-dimensional boundary layer does not correspond with the contemporary view of the question [see, for instance, the review in AMR **7**, 1954] and contains an inadmissably large number of assumptions, which either require special substantiation, or are incorrect. Thus, for instance, only one of the two equations regarding momentum for the three-dimensional zone is made use of; the conversion of the full speed w along the normal k of the wall y is taken to be the same as in the case of a two-dimensional layer, which contradicts known theoretical and experimental data [A. Mager, *NACA Repts.* 1067, 1085; *Ref.* Zh. Mekh, 1955, Rev. 1384]; the velocity profile w is chosen without regard to the pressure gradient; the tangential stresses are computed as a linear function y both for the turbulent and laminar layers; for the radius of curvature of flow lines in the boundary layer the gradual semi-empirical dependence is accepted as a criterion, which does not satisfy the boundary conditions indicated on p. 44; the solution of the deduced differential equation for the angle ϕ, the turning of velocity in the boundary layer, in spite of the supplementary simplifications (smallness of ϕ, discarding of several terms in the equation), is not obtained, also ϵ, the arbitrary constant, is not determined; ten boundary conditions for the sought-after thickness of the boundary layer δ are formulated without regard to the existence of blades and insufficient data for the calculation of function $\delta(u,Z)$ over the whole zone of its determination. The scheme of calculation of the method is extremely complicated and inapplicable in solving the numerical examples.

In the method recommended by the author for the calculation of profile losses, the losses due to mixing beyond the cascade are not taken into account, although methods are known (some of them are referred to by the author) which are free from this defect.

In calculating the losses connected with the terminal thickness of the trailing edges, use is made of experimental data, which refer not to the cascades but to the single laminar. When determining terminal losses, that part of them is not separated out which is connected with the presence of the boundary layer at the entrance to the cascade. The approximate method for determining velocities in the ducts, in its presented form, is not suited for calculations (not shown are means of finding the form of equipotential lines and curves for the linear flows). The formula, given on pp. 75, 76, is inadequate for the calculation of the exit angle of the flows, while formula (63) is obviously wrong, for in the case of a cascade with straight blades of any thickness equality is assigned to the angle of exit of the flow and the blade angle.

Courtesy Referativnyi Zhurnal G. Yu. Stepanov, USSR
Translation, courtesy Ministry of Supply, England

602. Carter, A. D. S., Kilpatrick, D. A., Moss, C. E., and Ritchie, J., An experimental investigation of the blade vibratory stresses in a single-stage compressor, *Aero. Res. Counc. Lond. curr. Pap.* 266, 13 pp. + 17 figs., 1956.

The compressor blade flutter investigation has so far been concentrated primarily on static cascades. As a link with full-scale compressor results, a series of tests has been undertaken on the untwisted stator of a single-stage compressor. The tests were carried out in a variable density return circuit rig. The results of the investigation can be summarized briefly:

(1) Stalled flutter, which appears to be identical with that experienced in cascades, can occur in a compressor.
(2) Stalled flutter occurred at all incidences above stall, for sufficiently high air velocities. In a few instances some evidence of a rotating stall cell was also observed.
(3) The critical flutter velocity is close to, but slightly lower than, that for a similar blade in cascade.
(4) There is no simple and direct relationship between flutter alternating stress and density.
(5) The maximum flutter alternating stress seems roughly independent of density, provided the air velocity is high enough, over the range of practical interest.
(6) The critical flutter incidence is independent of air density, i.e. of Reynolds number, over the range covered.
(7) The critical flutter velocity is a function of air density. Its variation is less than would be expected on theoretical grounds. The experimental variation is given in the text of the report.
(8) Buffeting stresses, i.e. miscellaneous alternating stresses under normal operating conditions, are proportional to the steady gas bending stress.

From authors' summary

603. Kittredge, C. P., Hydraulic transients in centrifugal pump systems, *Trans. ASME* **78**, 6, 1307–1322, Aug. 1956.

Differential equations of motion for (*a*) the rotating parts of the pump and prime mover and (*b*) the fluid in the pipes are derived. Methods of integrating the equations are discussed for the case of an assumed rigid fluid column and for the elastic fluid column. A hitherto unpublished solution for the elastic-column problem is described. Complete characteristics diagrams for several pumps are given. Solutions by different methods are compared and examples for actual installations shown.

From author's summary

604. Forshaw, J. R., An investigation of the high alternating stresses in the blades of an axial-flow compressor, *Aero. Res. Counc. Lond. Rep. Mem.* 2988, 19 pp., 1957.

605. Armitage, A., Notation for rotorcraft work, *Aero. Res. Counc. Lond. curr. Pap.* 314, 26 pp. +5 figs., 1957.

606. Castles, W., Jr., Approximate solution for streamlines about a lifting rotor having uniform loading and operating in hovering or low-speed vertical-ascent flight conditions, *NACA TN* 3921, 41 pp., Feb. 1957.

607. Roy, M., Energy considerations in jet propulsion (in French), Proceedings of the Eighth International Congress on theoretical and applied Mechanics, Istanbul, Turkey, Aug. 20–28, 1952, Vol. II, Part IV—General lectures and sectional addresses, pp. 137–162, Istanbul, Faculty of Science of the Univ. of Istanbul, 1955.

Author, assuming the asymptotic behavior of the perturbations produced in a uniform flow of a real (viscous and compressible) fluid by an obstacle, obtains the expressions of resistance and power for the propulsion of the same obstacle by applying the energy and momentum theorem to the fluid mass contained in a suitable control surface. There is first considered the case in which the body placed in the flow is *closed (dragged body)* and the case wherein the body is *open* and therefore has an orifice through which a gaseous fluid—derived from the chemical reaction—is ejected, which generates the energy usable for the propulsion (self-propelling body). Having suitably defined the *resistance* to self-propulsion, the efficiency of said self-propulsion is also defined, and, in the case of a *perfect* external fluid and *jet* self-propulsion, a comparison is made between the efficiency values of the aero jet and the rocket, respectively.

C. Ferrari, Italy

608. Johnson, A. E., Turbine disks for jet propulsion units, Parts, I, II, III, IV, V, *Aircr. Engng.* **28,** 328, 187–195, June 1956; **28,** 329, 235–243, July 1956; **28,** 330, 265–272, Aug. 1956; **28,** 331, 325–332, Sept. 1956; **28,** 332, 348–356, Oct. 1956.

Paper gives an account of work (so long unknown publicly) of the Disk Panel of the Ministry of Supply, Gas Turbine Collaboration Committee, during the years 1941–1949.

The first two parts of the paper provide a general examination of the stress and strain distribution in "cooled" thin disk. Both centrifugal loading and thermal expansion give rise to elastic stresses in the disk, and their effects are calculated separately. In this connection the following methods have been discussed: (1) Hartree's method of a numerical integration; (2) Donath's method of dividing the disk into a number of concentric rings; and (3) a modification of the preceding method by Royal Aircraft Establishment where only tabular computations are involved.

From total elastic stress distribution the plastic strain components for the radial and circumferential directions are calculated by the criterion of shear strain energy. The following stress-strain relationship for the plastic range has been found suitable:

$$x = \tfrac{1}{2} A_1 \{(X - Y)^2\}^{(n_1-1)/2} \{(X - Y) - (Z - X)\}$$

and corresponding expressions for y and z, where x, y and z are principal plastic strains, X, Y and Z are principal stresses and A_1, n_1 are constants having a wide range of values with different materials.

Creep in the disk was found unlikely to be of practical importance if the blade fastenings in the rim are adequate. A series of tests carried out on various materials comprised the following: (1) Thermal conductivity tests; (2) thermal expansion tests; (3) tensile and torsion tests; (4) relaxation tests; (5) reversals of strain tests; (6) overstrain of fatigue tests; lots of experimental data are incorporated.

Finally, complications introduced by the existence of the blade root fixings at the periphery have been dealt with.

S. C. Das, Canada

609. Baxter, J. R., Turbo-prop performance analysis and flight planning, *J. roy. aero. Soc.* **61,** 558, 391–406, Aug. 1956.

610. Sellerio, A., The high-speed diesel engine with deformable chamber (in Italian), *Termotecnica* **11,** 4, 179–182, Apr. 1957.

Flow and Flight Test Techniques

(See also Revs. 502, 544, 547, 550, 575, 592, 593)

611. Kobashi, Y., Measurements of pressure fluctuation in the wake of cylinder, *J. phys. Soc. Japan* **12,** 5, 533–543, May 1957.

Condenser-microphone-type pressure pickup was developed for measuring turbulent pressure fluctuations, and a single rotating hot-wire anemometer was used to measure different combinations of velocity components. Author was able to measure in the wake of a cylinder the turbulent intensities as well as single-point double and triple velocity correlations. In combination with the pressure pickup velocity, pressure correlation was measured (the first reported measurement to the best knowledge of reviewer), and the turbulent energy balance equations verified.

L. S. G. Kovasznay, USA

612. Wahl, A. M., Recent research on flat diaphragms and circular plates with particular reference to instrument applications, *Trans. ASME* **79,** 1, 83–87, Jan. 1957.

613. Mair, W. A., Davidson, I. M., Greatrex, F. B., Warren, H. E., Young, A. D., Rogers, E. W. E., Report of the pressure panel on the definitions of quantities having the dimensions of pressure, *Aero. Res. Counc. Lond. curr. Pap.* 281, 4 pp., 1956.

614. Nakagawa, Y., Okuda, S., and Oyabu, M., Study on a new rotational oscillating viscometer (in Japanese), *Chem. Engng. Japan* **20,** 481–487, Sept. 1956.

The object of the report is to explain the result of the investigation on a new rotational oscillating viscometer with two coaxial cylinders designed by the authors. Coefficient of viscosity of liquid under test is obtainable from the logarithmic decrement λ of the damped oscillation of the inner hollow cylinder suspended by a steel wire of small diameter.

As seen from the relation between λ and the dipped height of the inner cylinder in liquid, the end effect of this apparatus is negligibly small as compared with that of the ordinary viscometer of rotating cylinder type with a bottom plate.

The relation λ versus η is recognized to be straight in the region $\eta > 1$ poise, but it deviates from the straight line where the viscosity is as low as $\eta < 1$ poise. Usually this viscometer can be applied to the measurement of viscosity in the wide range of η above 1 poise. Even when the viscosity is low, ($\eta < 1$ poise) it may be used keeping the sensibility of 0.1 centipoise by setting a torsion wire of smaller diameter, although in this case it does not give the linear relation between λ and η as before.

Y. Mori, Japan

615. Kislinskii, A. N., and Kusakov, M. M., An apparatus for determining the characteristics of the influence of temperature on the viscosity of lubricating oils (in Russian), *Zavod. Lab.* **21**, 1, 102–105, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6110.

A description is given of a new development of the method, using the sinking ball viscometer, for study of the temperature influence on the viscosity of lubricating oils.

A glass cylinder filled with oil is arranged vertically and a steady distribution of temperatures in a wide range of low temperatures obtained by the aid of refrigerating apparatus with liquified gas (N, air, or O) or on solid CO_2. In carrying out of the experiment, the first step was to determine the temperature along the axis of the oil column (trajectory of the falling ball) using a cupro-nickel thermocouple and galvanometer; then the speed of the falling ball is determined, measuring the time taken to pass successive parts of the path of the steel ball or drop of liquid HCl by means of a stop watch and microscope (MIR-1). The method of using the results of the experiment includes the determination of the instantaneous speed of the falling ball by means of graphical differentiation of the experimental curve dealing with the relation of the path passed by the ball to the time taken; then the relation of the found instantaneous speed to the temperature of the oil is determined, the given measurements of temperature distribution of the oil by height being known; and finally the calculation is made for the value of the dynamic viscosity using the customary Stokes' formula. For oils with high temperature gradients (above 15 poise/°) a correction to Stokes' formula is inserted, which consists in the division of the viscosity values calculated by this formula by the empirical correctional factor

$$K = \alpha\,(dn/dt) + b$$

where α and b are constants ($\alpha = 333 \times 10^{-5}$, $b = 0.969$).

Courtesy Referativnyi Zhurnal B. D. Zaloga, USSR
Translation, courtesy Ministry of Supply, England

616. Kompanects, V. Ya., The experimental determination of the viscosity of gases and gas mixtures at high temperatures (in Russian), *Sb. nauch. rabot* **9**, 113–126, 1953; *Ref. Zh. Mekh.* 1956, Rev. 6107.

A scheme is given with a detailed description of a viscometer with quartz capillary, specially designed to determine the viscosities of gases at high temperatures. The theory of the apparatus is propounded, and the solution of the working formulas for the coefficient of visoosity is given, it being assumed that the principle of the distribution of velocities in the capillary is of a parabolic nature, and that the difference of pressure measured in the experiment corresponds actually to the difference of pressure at the ends of the capillary. The error, due to the incomplete compliance with the accepted conditions, is evaluated.

Three tables are given to indicate the values of the viscosity coefficients of air, CO_2, and H at different temperatures (up to 800°) which were obtained by the author using the described apparatus, and the values of the viscosity coefficients of the same gases as known from the literature.

Courtesy Referativnyi Zhurnal N. A. Zaks, USSR
Translation, courtesy Ministry of Supply, England

617. Borden, A., Time constants and frequency response of coated hot wires used as turbulence-sensing elements, *David W. Taylor Mod. Basin Rep.* 952, viii + 50 pp., June 1957.

A theoretical study is presented for the transient response for a hot-wire anemometer consisting of a cylindrical metal wire with an insulating coating of a generally poor thermal conduction. The study is motivated by a hope to use coated wires in water. The heat-conduction equations are linearized and the imposed disturbances are step functions of time. The transient responses are calculated for three cases. Step function in change of heating current or in convective cooling for the constant-current-type anemometer and step function change in the convective cooling for the constant-temperature feedback-type of anemometer. Author does not seem to be aware of *NACA TN* 3514, treating a two-material concentric cylinder's response.

L. S. G. Kovasznay, USA

618. Brik, P. M., and Grosman, D. A., The results of investigations of the hydraulic resistance of throttle plates (in Russian), *Naladochnye i ekhsperim. raboty ORGRES* no. 9, 33–37, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5914.

The experimental determination of the hydraulic resistance of throttle plates is described, adaptable for extinguishing excess pressure of water in local systems of heating and ventilation which are fed from a heating network and not furnished with automatic apparatus of control.

Based on the data obtained, it is shown that the coefficient of discharge is the coefficient of the ratio between the diameter of the opening in the plate and the diameter of the pipe and the ratio between the thickness of the plate and the diameter of its opening. The meaning of the coefficient of discharge is stated. It is obtained by experimental methods and calculated by means of formulas ordinarily accepted for adaption in this type of work.

Practical indications are given for the determination of reliable values of the indicated coefficient, corresponding to the working data. E. Z. Rabinovich, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

619. Halliday, A. S., and Cox, D. K., Note on the effect of size and position of end plates on the lift of a rectangular wing in a wind tunnel, *Aero. Res. Counc. Lond. curr. Pap.* 305, 5 pp. + 12 figs., 1956.

Thermodynamics

(See Revs. 555, 598, 607, 610, 615, 616, 664)

Heat and Mass Transfer

(See also Revs. 409, 419, 528, 543, 549, 550, 552, 559, 699, 710)

620. Friedmann, N. E., Quasilinear heat flow, ASME–AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-10, 10 pp.

The unsteady heat-conduction equation is a nonlinear partial differential equation when the heat conductivity is considered to vary with temperature. In the first part of the paper bounds are established for the effects of this property variation on the heat-conduction process. In the second part solutions are described to a number of specific problems. In all of them a constant initial temperature is assumed. For a semi-infinite solid with one-dimensional heat flow and constant heat flux into the boundaries, a solution is obtained by linearization. With constant surface temperature, the differential equation may be transformed to an ordinary one. The heat conductivity is, in both cases, prescribed by a power function. For a slab with finite thickness, one-dimensional heat flow, and constant surface temperature, solutions have been obtained on an analog. The heat conductivity was in this case assumed to vary linearly with temperature. All these solutions are compared with the results of constant-property calculations, and the magnitude of the deviations caused by the variation of properties is investigated.

E. R. G. Eckert, USA

621. Landis, F., The effectiveness of stub-fins as determined by the Teledeltos paper analog, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-20, 12 pp.

The heat-conduction process through stubby rectangular and triangular fins is investigated by an electric analog using the Teledeltos paper. The results are compared with exact analytical solutions and it is demonstrated that, with proper care, an accuracy better than ± 2% can be obtained.

E. R. G. Eckert, USA

622. Boeschoten, F., and Van Der Held, E. F. M., The thermal conductance of contacts between aluminum and other metals, *Physica* **23,** 37-44, 1957.

The coefficient of heat transfer of a joint between aluminum and aluminum, steel and uranium respectively was measured. The gap between the metal surfaces was filled with air, helium or hydrogen of gas pressures varying between 1 mm Hg and 750 mm Hg. Some oils also were introduced in the joint. The temperature of the joint was about 150 C in all experiments.

It appears that at low contact pressures of several kgf cm^{-2} the heat conduction takes place principally through the gas in the gap, whereas at higher contact pressures the metallic contact spots contribute more and more to the conductance. This is in agreement with the measurements of Weills and Ryder.

Calculation of the thickness of the gap from heat conductance measurements are in rough agreement with roughness measurements with a profilometer and a microscope.

An estimation is made of size and the number of the metallic contact spots, using the theory for electric contacts of Holm and others. From thermal conductance and hardness measurements the average radius of the contact spots is found to be about 30 μ, whereas about 100 of such spots may be found per square centimeter at a contact pressure of 35 kgf cm^{-2}.

The contact pressure has not much influence on the size of the contact spots, but their number varies proportionally with the contact pressure. Above a certain value of the contact pressure a confluence of the contact spots takes place and a decrease of their number.

Moreover it seems that the size of the contact spots is independent of the metals by which the joint is formed, a value of about 30 μ being found for a great variety of metals, such as aluminum, uranium, steel, copper, nickel and graphite, under different circumstances, regarding the applied contact pressure and the size and the shape of the joints.

This independence of the size of the contact spots of the contact pressure, and the materials of the joint, makes it possible to estimate the coefficient of heat transfer of arbitrary metallic joints. From authors' summary

623. Sparrow, E. M., and Gregg, J. L., Nonsteady surface temperature effects on forced convection heat transfer, *J. aero. Sci.* **24,** 10, 776-777, Oct. 1957.

An analytical study was made of the deviations of the instantaneous heat transfer from the quasi-steady-state value. The system was a semi-infinite flat plate; steady free-stream velocity with compressibility included.

The deviations were a function of the boundary conditions with respect to both sign and magnitude. The deviations were negligible in the example selected. W. L. Sibbitt, USA

624. Whiteman, I. R., Heat transfer between a flat plate and a fluid containing heat sources, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-4, 3 pp.

Paper deals with an extension of the Lévêque solution for a flat plate by including a uniformly distributed heat source in the fluid. The energy equation in its usual simplified form for longitudinal, laminar flow of an incompressible fluid along an infinite flat plate was integrated under the assumption of constant fluid properties and linear velocity distribution. This equation was first converted into a second-order, ordinary differential equation by using the Laplace transformation. Certain approximations were introduced in the determination of the integration constants. Expressions were obtained (1) for the heat flux through the plate when its surface temperature was prescribed and (2) for the plate temperature when the heat flux was prescribed.

B. T. Chao, USA

625. Winovich, W., and Stine, H. A., Measurement of the nonlinear variation with temperature of heat-transfer rate from hot wires in transonic and supersonic flow, *NACA TN* 3965, 33 pp., Apr. 1957.

This note presents an analysis of characteristics of hot-wires operating throughout the Mach numbers 0.3 to 2.5. A portion of the analyzed data was published previously by one of the authors. Present data correspond to 0.00015- and 0.00030-in.-diam tungsten wires, Mach numbers from 0.5 to 2.5, Reynolds numbers from 18 to 144, Knudsen numbers from 0.12 to 0.005. The equilibrium-to-total-temperature ratio is characterized by a constant recovery factor, up to a Mach number of 0.9. For supersonic Mach numbers, that ratio maintains a constant value up to a Knudsen number of about 0.15. For constant temperature potential, the Nusselt number is a function of the Mach and Reynolds numbers only. In the transonic Mach number range, the heat-loss characteristic depends primarily on Knudsen number. The degree of nonlinearity between heat-transfer rate and wire temperature potential is determined jointly by the Reynolds number and the Mach number. For a given Reynolds number the maximum nonlinear effect occurs at Mach number 1. Experimental results are given in two tables and six figures.

E. G. Macagno, Argentina

626. Pridmore-Brown, B. N., Heat transfer in a laminar boundary layer at Mach 2.5 from a surface having a temperature distribution, *Univ. Toronto Inst. Aerophys. Rep.* 45, 19 pp. + 47 figs., Feb. 1957.

Heat transfer is measured on outer surface of hollow cylinder with sharp leading edge. Five different surface-temperature distributions are studied. In each case, heat transfer is higher (up to 100%) than Chapman-Rubesin theory. Boundary-layer total-pressure surveys showed similar discrepancy. Note is made of previous experiments on flat plate which have shown similar discrepancies with theory near leading edge, but not farther downstream. In present experiments, occurrence of transition prevented study farther downstream than about 3 inches from leading edge. Previous experiments on bodies of revolution generally agree well with laminar boundary-layer theory. Consequently, one factor possibly contributing to discrepancy is leading-edge effect. Reason or reasons for discrepancy are not established, however. D. R. Chapman, USA

627. Manson, S. V., Gas-friction—Heat-transfer charts for ducted flows, ASME-AIChE Heat Trans. Conf., University Park, Pa., August 1957. Pap. 57-HT-34, 3 pp.

Charts that speed heat-exchanger calculations and aid analysis of other ducted gas flows are illustrated, and examples of their use are presented. From author's summary

628. Zellnik, H. E., and Churchill, S. W., Convective heat transfer from high-temperature air inside a tube, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-33, 8 pp.

Local rates of convective heat transfer from air at high temperature to a cold wall were measured in the inlet region of a circular tube. Air entered the tube with a flat velocity and tem-

perature profile at temperatures from 480 to 2000 F and flow rates corresponding to bulk Reynolds numbers from 4500 to 22,500. The inner surface of the 1.0-in.-ID tube was maintained at approximately 100 F by water cooling. Local rates of heat transfer were determined at 1.5, 4, 7, and 10 tube diameters from the entrance by measuring the radial temperature profile in thermally isolated, annular sectors of the tube wall. The local rate data for all gas temperatures are well represented by previous correlations for small temperature differences if the gas properties are evaluated at the bulk temperature rather than the film temperature. The data agree well with the data of previous investigators wherever the experimental ranges overlap. From authors' summary

629. Massimilla, L., Bracale, S., and Cabella, A., On heat transmission in unbaffled and baffled fluidized solid-gas systems (in Italian), *Ric. sci.* **27,** 6, 1865-1867, June 1957.

Authors report the results of a series of heat-transmission tests on air-fluidized baffled and unbaffled solid-gas systems. The tests were performed on beds of variable height, consisting of 0.7-mm glass pellets, and fluidized by an air stream of different velocity. In all tests the thermal coefficients were determined for the fluidized interior surface of column, at various heights, corresponding to each of the theoretical elements making up the fluidization column.

The values of the heat-transfer coefficients along the column axis for the unbaffled fluidization tests are then compared with those relating to the baffled fluidization tests. This comparison shows that the values of the heat-transfer coefficients both in the baffled and unbaffled fluidized systems are practically the same. From authors' summary

630. Nakagawa, Y., Experiments on the inhibition of thermal convection by a magnetic field, *Proc. roy. Soc. Lond.* **(A) 240,** 1220, 108-113, Apr. 1957.

Experiments on the magnetic inhibition of thermal convection in horizontal layers of mercury heated from below are described. A large 36½-in. cyclotron magnet reconditioned for hydromagnetic studies was used in these experiments. By using layers of mercury of depth 3 to 6 cm and magnetic fields of strength 500 to 8000 gauss, it has been possible to determine the dependence of the critical Rayleigh number for the onset of instability on the parameter Q_1 ($= \sigma H^2 d^2/\pi^2 \rho \nu$, where H denotes the strength of the field, σ the electrical conductivity, ν the coefficient of kinematic viscosity, ρ the density and d the depth of the layer) for Q_1 varying between 40 and 1.6×10^6. The experiments fully confirm the theoretical relation derived by Chandrasekhar. From author's summary

631. Hool, J. N., Local coefficients of skin friction and heat transfer for turbulent boundary layers in two-dimensional diffusers, *Aero. Res. Counc. Lond. Rep. Mem.* 2986, 12 pp., 1957.

Report considers the changes of local coefficients of skin friction and heat transfer for turbulent boundary layers in two-dimensional subsonic air streams under rising pressure gradients.

The values of the local coefficients of skin friction and heat transfer are compared on the basis of Reynolds' analogy, von Kármán's improvement to Reynolds' analogy, and on the basis of similar velocity and temperature boundary-layer profiles.

Tests on diffusers at total angles of 4° and 7° showed that the local coefficients of heat transfer, based on the measured heat-transfer values, increased with increase of the stream velocity and diffuser angle relative to the local coefficients of heat transfer, based on Reynolds' analogy and on von Kármán's improvement to Reynolds' analogy. The local coefficients of heat transfer calculated on as assumed similarity of velocity and temperature distributions were unsatisfactory. From author's summary

632. Farbar, L., and Morley, M. J., Heat transfer to flowing gas-solids mixtures in a circular tube, *Indust. Engng. Chem.* **49,** 7, 1143-1150, July 1957.

Data from an exploratory study of silica-alumina catalyst and air are applicable to industrial heat-recovery equipment. From authors' summary

633. Esgar, J. B., Livingood, J. N. B., and Hickel, R. O., Research on application of cooling to gas turbines, *Trans. ASME* **79,** 3, 645-651, Apr. 1957.

The use of turbine cooling in gas-turbine engines can offer many performance benefits but, at the same time, it may result in added complication to the engine. The advantages that turbine cooling can offer to the engine designer and the results of some of the research that has been expended on the cooling of gas-turbine engines are discussed. From authors' summary

634. Wender, L., and Cooper, G. T., Heat transfer between fluidized solids beds and boundary surfaces—correlation of data, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-31, 25 pp.

A broad empirical study of nine independent sets of data on fluidized-bed heat transfer is presented, with correlation of the data in two groups. A wide range of the many variables is covered, and some data on commercial units are included. Data for external heat-transfer surface (i.e., walls of the fluidizing vessels) are correlated graphically as a curve of $hD_p/[k_g(1-\epsilon)(c_s\rho_p/c_g\rho_g)(1+7.5e^{-0.44(L_H/D_T)/(c_s/c_g)})]$ versus D_pG/μ and those for internal heat-transfer surface (i.e., tubes in the bed) as $(hD_p/k_g)(k_g/c_g\rho_g)^{0.43}/[(1-\epsilon)(c_s/c_g)^{0.80}(\rho_p/\rho_g)^{0.66}C_R]$ versus D_pG/μ. The correlations indicate importance of heat transport by the mobile particle and of unsteady-state conduction in the gas. From authors' summary

635. Grant, W. L., The nature of the air flow through and the heat transfer from a grid of parallel bars, *So. African Counc. sci. indus. Res.*, 32 pp., Sept. 1955.

Paper describes the design and the experimental work associated with the development of a permeable wall, which, though allowing air to flow through it with the minimum of aerodynamic disturbance and the lowest possible heat transfer, allows its mean radiant temperature to be controlled up to 30F above or below air temperature.

The design is discussed from the point of view of obtaining the minimum heat flow to the airstream, and of insuring that the mean radiant temperature of the wall is constant over the entire surface when viewed from angles of 90° to 45° to the plane of the wall.

Test results are given of the velocity distribution at various distances downstream from the experimental bar-grid wall, of the turbulence in the airstream at various downstream positions, and of the pressure loss across the wall. Results are also given of the film coefficients between the heated bar-grid faces and the airstream, of the temperature distribution in the airstream downstream from the bar-grid wall, and of the measured mean radiant temperature distribution of the wall when viewed from different angles. The radiation was measured for the bar-grid wall as manufactured from the original plastic material and for the case when thin aluminum foil was pasted to the sides of the grid bars. It was found that, with the aluminum foil, the bar-grid wall gave a mean radiant temperature distribution well within the required limits. From author's summary

636. Kuo, H.-L., Forced and free axially-symmetric convection produced by differential heating in a rotating fluid, *J. Meteor.* **13,** 6, 521-527, Dec. 1956.

When heat is applied to the outer portion and removed from the inner portion of a rotating fluid, a forced direct symmetric convec-

tion is set up. The intensity of this motion is directly proportional to the rate of heating and inversely proportional to the square of the rate of rotation. It therefore must be very weak when the rate of rotation is large. However, when the temperature gradient becomes higher than a certain upper limit, a more violent symmetric convection will occur. This violent convection may be considered as an amplifying free convection, or a forced convection under near-resonance conditions.

The criterion for this upper transition is obtained in this article by a simple method and expressed in terms of a Richardson number which combines the effects of rotation, static stability, viscosity, conductivity, radial temperature contrast, and the relative vorticity of the mean zonal flow into a single parameter. A comparison between this criterion and Fultz' experimental results suggests that the relative vorticity of the mean zonal current has a larger effect on this transition at lower rotation rates.

From author's summary

637. Chirkin, V. S., Systems of heat removal from nuclear reactors, *J. nuclear Energy* **5,** 1 (part 2), 124–134, 1957.

Different ways of using power plant and coolant to extract the heat evolved in a reactor core are described. A classification is given of heat extraction systems in which water, boiling water, aqueous solutions, gases, and liquid metals are used as coolant.

From author's summary

638. Blazey, S. H., The design and application of thermostats to the internal-combustion engine cooling system, Instn. mech. Engrs. Auto. Div., Prepr., 8 pp., 1957.

The history of the thermostat is shown and also the way in which effective engine-coolant temperature control has been obtained through the years.

The main reasons for the use of thermostats are (1) lower engine wear, (2) improved thermal efficiency, and, (3) requirements of the modern car heater.

The basic design requirements for the ideal engine thermostat are enumerated, and paper discusses how near the modern thermostat comes to these requirements. The poppet-type and butterfly-type valve are used for thermostats, the advantages and disadvantages of each type being discussed. The main problem is dirt which becomes trapped in the valve seating, and increases the warm-up time of the cooling system.

The design features of the bellows-type and wax-type thermostat, and the fillings used in the bellows type are discussed. The damping of vibration periods by hydraulic and friction methods are shown. The wax-type thermostat has gained popularity because of its insensitivity to pressure when the coolant system is pressurized. The heat transfer of the wax pellet is slower than the vapor in the bellows type, and the reasons for this are given. Thermostat installations are discussed and illustrated.

From author's summary

639. Jackson, T. W., Harrison, W. B., and Boteler, W. C., Combined free and forced convection in a constant-temperature vertical tube, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-13, 7 pp.

Data are presented for flow in a tube with an over-all length-diameter ratio of 16 and values of the Graetz modulus based on the bulk or average air temperature from 40.2 to 1710. The product of the Rayleigh number based on wall conditions and the diameter-length ratio ranged from 1.05×10^8 to 1.30×10^6. A Nusselt number formula is presented which correlates the data better than that given by Martinelli.

Authors seem to be unaware of work on the same problem by Hallman [AMR **9,** Rev. 1989; also *Trans. ASME* **78,** no. 8, Nov. 1956] and others referenced by him. Comparison of results would have been interesting. S. Ostrach, USA

640. Schechter, R. S., Natural convection heat transfer in regions of maximum fluid density, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-25, 28 pp.

Free convection about a vertical flat plate of fluids with a density maximum is studied. Specific consideration is given to water which has a density maximum at 4° C. In such a case it is pointed out that the buoyancy force can (depending on the plate temperature) act in two different directions and, therefore, fluid motion should occur in both an upward and a downward direction simultaneously.

Experiments and theoretical calculations made for conventional (unidirectional) free convection flows of water at Prandtl numbers near 10 are first shown to be in reasonable agreement. The theoretical calculations were obtained from a Kármán-Pohlhausen integral method and an electronic analog computer. The former method is then used to compute Nusselt numbers for the case of flow in two directions. Again good agreement with experimental results is obtained.

A criterion is established to define when the unidirectional and the other type flows should be encountered.

S. Ostrach, USA

641. Genensky, S. M., A problem in self-heating of a spherical body, *J. Res. nat. Bur. Stands.* **59,** 2, 79–81, Aug. 1957.

An analytic steady-state solution is developed for a spherical body in which heat is generated according to a first-order unimolecular-reaction law, and lost at the surface in accordance with Newton's law of cooling. The temperature within the sphere depends chiefly on the radial distance from the center, but also on the ambient temperature, the surface heat-loss coefficient, and the material properties, which are assumed constant.

From author's summary by H. Blok, Holland

642. Thomas, D. B., and Townsend, A. A., Turbulent convection over a heated horizontal surface, *J. fluid Mech.* **2,** 5, 473–492, July 1957.

Paper constitutes a major contribution to the understanding of free convection in air from horizontal surfaces facing upward, with and without a cold upper boundary. The experimental work provides observations of the heat transfer, the mean temperature profiles, and the mean squares of the temperature fluctuations. The results are compared with the "similarity" theory of Priestley and the "neutral stability" theory of Malkus. Both these theories lead to the conclusion that, for convection between parallel planes at high Rayleigh numbers, nearly the whole of the mean temperature variation occurs in comparatively thin surface layers whose mutual interaction is small. The present experiments confirm this in some detail, but the exact form of the variation of mean temperature cannot be completely reconciled with either of the theories. This work is a most welcome contribution to a field which has received little attention. Y. S. Touloukian, USA

643. LeFevre, E. J., Laminar free convection from a vertical plane surface, Mech. Engng. Research Lab. Heat 113, 5 pp., Aug. 1956.

Solutions of Schmidt and Beckmann's boundary-layer equations are derived for the limiting cases of infinite and zero Prandtl group. The following interpolation formula represents the results, as well as those computed by Ostrach [AMR **5,** Rev. 3233], for definite values of N_{Pr} ranging from 0.01 to 1000:

$$N_{Nu}^4 = N_{Gr} N_{Pr}^2 / (2.43478 + 4.884 N_{Pr}^{1/2} + 4.95283 N_{Pr})$$

H. A. Vreedenberg, Holland

644. Lefevre, E. J., and Ede, A. J., Laminar free convection from the outer surface of a vertical circular cylinder, Mech. Engng. Research Lab. Heat 114, 6 pp. + 1 fig., Sept. 1956.

It is assumed that two parameters occur in the temperature and velocity profiles: a boundary-layer thickness and a representative velocity. Writing these as power series in $1/D$, the following approximative solution of the boundary-layer equations is obtained:

$$N_{Nu} = (4/3)\{7N_{Gr}N^2_{Pr}/5(20 + 21N_{Pr})\}^{1/4} + 4(272 + 315N_{Pr})L/35(64 + 63N_{Pr})D$$

where L is the height and D the diameter of the cylinder, and N_{Nu} and N_{Gr} are based on L. Comparison with results of experiments with air and other gases from literature proves the applicability of this equation even when $N_{Gr}^{1/4} D/L$ is as small as 0.001 so that the approximations made are invalid. Reviewer remarks that for infinite D/L and zero N_{Pr} there is no agreement with the exact solution for a vertical plane surface given in Le Fevre's accompanying paper (see preceding rev.).

H. A. Vreedenberg, Holland

645. Vernotte, P., On some recent experiments on heat convection and energy transformation (in French), *Publ. sci. tech. Min. Air, France NT* 61, 21 pp., 1956.

Author's law on natural convection is

$$h = A + BT^{1/4} + C^{7/4}$$

in which h is the convection coefficient; A,B,C, constants, T the difference of temperature.

The application of this law to some recent experiments on heat convection of thin wires in air shows that the convection coefficient does not depend upon the nature of wires.

C. Codegone, Italy

646. Yastrebenetskii, A. R., Nomograms for determination of the coefficients of thermal emission (in Russian), *Trudi Kharkovsk. politekhn. in-ta*, **4**, 189–201; *Ref. Zh. Mekh.* 1956, Rev. 5253.

Nomograms are constructed for determination of the coefficients of heat emission in the case of natural convection in an unlimited volume, for the forced motion of a liquid in pipes (laminar and turbulent), and for film condensation of a slowly-moving pure dry saturated vapor for the case of a laminar flow of the film.

The limits of application of the empirical formulas used for construction of the nomograms are not mentioned in a number of cases, and in some cases are given incorrectly. For example, author states that formula [5] for heat emission in the case of turbulent motion of a liquid in pipes is correct at values of Prandtl's number of $0.7 < P < 2500$. In actual fact it is correct only at $0.7 < P < 150$.

In the calculation of the heat emission from condensing vapor, author suggests selecting the latent heat of vapourization r at wall temperature, but it is well known that the value r should be selected at the saturation temperature of the vapor.

Courtesy Referativnyi Zhurnal B. S. Patukhov, USSR
Translation, courtesy Ministry of Supply, England

647. Alemasov, V. E., Convective thermal emission of transversely washed pipe surfaces at various temperature conditions (in Russian), *Trudi Kazansk. aviats. in-ta* 29, 160–182, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5252.

An experimental investigation of a five-series corridor bundle having $d = 40$ mm $s_1 = s_2 = 60$ mm for Reynolds numbers between 12.5×10^3 and 149×10^3 and T_p/T_{st} from 0.50 to 1.53.

Courtesy Referativnyi Zhurnal V. S. Zhukovskii, USSR
Translation, courtesy Ministry of Supply, England

648. Chekayuk, E. B., The temperature field of a layer when the heat carrier is forced under pressure into a slit (in Russian), *Neftyanoe kh-vo* no. 4, 39–43, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5994.

The problem is examined of the plain radial heat flow. Article represents further developments of the basic data of the author's initial work [*Ref. Zh. Mekh.* 1955; Rev. 2545]. In setting up of the basic differential equation regarding the layer temperature, only the effect of the heat conducting and convection heat exchange was taken into account, while heat losses through the top and bottom of the layer were disregarded. The derived differential equation for the problem of the temperature field of the layer has an initial temperature T_n = const, while at temperature T_i = const the heat carrier is pressurized. The corresponding solution is shown as

$$T = T_n + \frac{Ti - Tn}{S(0)} S(x) \quad \left(x = \sqrt{\frac{Cn}{4\lambda t}} r\right)$$

$$S(x) = \int_x^\infty e^{-x^2} x^{2k-1} dx$$

where c_n is heat capacity of the layer; λ coefficient of heat conductivity; r polar radius; t period of flow, k some number, depending on the rate of pressurizing. V. P. Pilatovskii, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

649. Andrews, S. J., Ogden, H., and Marshall, J., Some experiments on an effusion cooled turbine nozzle blade, *Aero. Res. Counc. Lond. curr. Pap.* 267, 22 pp. + 14 figs., 1956.

An experimental and theoretical investigation is carried out on effusion cooling of a turbine nozzle blade in a cascade tunnel. The permeable surface of the test blade is made of woven stainless steel wire cloth brazed to the spine in such a way that the effusion flow can be individually controlled over a number of regions on both convex and concave surfaces of the blade form. In this way, the chordwise effusion, flow distribution required to produce uniform surface temperature at midspan, and the temperature distribution at mid-span produced by uniform effusion are determined and compared with the corresponding theoretical predictions.

In the laminar flow region of the blade boundary layer the effusion flow to achieve a required temperature is much higher than predicted, and in the turbulent flow region the flow is lower than predicted. The two requirements combine to give an over-all cooling effectiveness for the blade surface which is very little different from an internally cooled impermeable rotor blade also tested in a cascade. The large effusion flow required in the laminar region may be due to the practical limitation of the number of individually controllable effusion regions since the static pressure gradient over the leading edge part of the blade surface is very large and the variation in effusion cooling air supply pressures required must also, therefore, be very large.

The solution to this problem lies in the use of permeable materials of either variable permeability or variable thickness over a relatively wide range of permeability or thickness.

From authors' summary

650. Dhanak, A. M., Momentum and mass transfer by eddy diffusion in a wetted-wall channel, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-32, 14 pp.

The role of eddy diffusion of mass (water vapor) and momentum was investigated in a specially devised wetted-wall channel in which the rippling of the liquid film was eliminated. The experimental measurements of the turbulent exchange coefficients for mass and momentum transport were carried out in a fully developed turbulent flow of air within the range of Reynolds numbers of 8000 to 160,000. A correlation with Reynolds numbers revealed an approximately linear relationship of the eddy diffusivities to Reynolds number. From the hot-wire measurements it was found that, within the main portion of the turbulent core, eddy diffusivities remained fairly constant. From author's summary

651. Goodman, T. R., The heat balance integral and its application to problems involving a change of phase, Heat Trans. and Fluid Mech. Inst., Calif. Inst. Techol., Pasadena, Calif., June 1957, 383–400.

This paper is of considerable importance. It introduces a novel method for approximate solution of the diffusion equation. It visualizes the temperature in a (one-dimensional) conducting solid (prior to reaching equilibrium conditions) as $u(x,\delta)$ to the left of $x = \delta(t)$, 0 (the initial value) to the right of $\delta(t)$. $u(x)$ is a polynomial which connects the imposed boundary value at $x = 0$ with 0 at $x = \delta(t)$; the coefficients are determined by the familiar techniques of boundary-layer theory. $\delta(t)$ is determined from an appropriate (usually nonlinear) differential equation. (The x of boundary-layer theory is now the time variable, the y of boundary-layer theory is now the x variable.)

Author treats by this method (a) the case of the semi-infinite solid subject, at $x = 0$, to a time-variable heat input; (b) the melting of a solid with fixed boundary temperature; (c) the melting of a solid with given time-variable heat flux at the boundary; (d) melting due to aerodynamic heating; (e) melting, with removal of melts; (f) vaporization of a melting solid. Adequate to good agreement is found with available rigorous solutions. [One may contrast the present method with the somewhat cruder method of N. Rashevsky ["Math. Biophysics," U. Chicago Press, 1948] and H. D. Landahl [*Bull. math. Biophysics* p. 49, 1953] who assumed $u(x,\delta)$ completely, and had to determine only $\delta(t)$ (from a suitable differential equation).] G. Horvay, USA

652. Hartunian, R. A., and Sears, W. R., On the instability of small gas bubbles moving uniformly in various liquids, Heat Trans. and Fluid Mech. Inst., Calif, Inst. Technol., Pasadena, Calif., June 1957, 23–42.

The transition between rectilinear and oscillating motion of rising bubbles is studied analytically and experimentally. It appears that either a critical Webber number or a critical Reynolds number can cause transition. Qualitative agreement exists with the data for pure fluids, but it appears that the properties of contaminated liquids are incompletely described by existing dimensionless groups. P. Griffith, USA

653. Styrikovich, M. A., Shitsman, M. E., and Miropol'skii, Z. L., Certain data on the temperature region of vertical boiler pipes at near-critical pressures, *Teploenergetika* **3,** 32–36, 1956.

Experimental investigation of pipe wall temperatures and heat-transfer coefficients for water boiling in a tube of 29-mm inner diam at pressures of 212 to 220 kg/cm² with heat inputs of 140,000 to 460,000 kcal/m²hr and mass velocities of 150 to 2420 kg/m² sec. Tube temperatures were measured with thermocouples embedded in the pipe wall. Heat inputs were obtained by using an electric radiation heater which surrounded a 300-mm length of tubing. Properties of steam in the heated section were determined by assuming equilibrium and making an energy balance on fluid.

Authors report results which may be interpreted as indicating a transition from nucleate to film boiling. Tests show that this transition, as evinced by large increase in tube wall temperature, may occur suddenly. For example: for slightly subcooled liquid entering test section at pressure of 220 kg/cm², mass velocity 436 kg/m²sec, the transition occurred quite suddenly as the heat input was increased past 120,000 kcal/m². Similar sudden transitions were observed for the case of steam of less than 40 to 45% quality entering the test section. When steam of greater quality (60 to 70%) entered the test section, no sudden transition was observed.

Reviewer believes that these experimental results should be of interest to those involved in the design of steam generators operating near the critical pressure. R. L. Young, USA

654. Harrison, W. B., and Levine, A., Wetting effects on boiling heat transfer, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-29, 10 pp.

In order to study effects of wetting on heat transfer in the nucleate boiling regime, stearic acid was boiled in contact with different crystal planes of single crystals of copper. One crystal plane was wetted by the acid and the other was not. In the region of low heat flux, where heat transfer is primarily nonboiling natural convection, the nonwetted crystal required higher values of temperature difference than the wetted crystal for the same flux. This is consistent with the notion that, for heat transfer without phase changes, nonwetting conditions represent increased thermal resistance. At high values of heat flux, though not in the vicinity of the critical temperature difference, the situation was reversed; that is, the nonwetted surface required lower temperature difference than the wetted surface. This is consistent with the notion that it is easier to form bubbles with nonwetting conditions than it is with wetting conditions. In the present studies, stearic acid was boiled at about 465 F, corresponding to a pressure of 17 mm of mercury. Heat flux ranged from 3450 to 63,300 Btu/hr sq ft, while temperature difference between the copper crystal and the stearic acid ranged from 38 to 132 deg F. The corresponding range of heat-transfer coefficient was from 91 to 510 Btu/hr sq ft deg F. From authors' summary

655. Cohen, L., and Fritz, W. A., Jr., Heat-transfer studies of naval boilers, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-8, 8 pp.

656. Wilde, K. A., An approximate specific impulse equation for condensation gas mixtures, *Jet Propulsion* **27,** 6, 668–669, June 1957.

657. Hurwicz, H., and Tischer, R. G., Heat transfer work in food processing field, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-18, 8 pp.

658. Gudheim, A. R., and Donovan, J., Heat transfer in thin-film, centrifugal processing units, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-22, 7 pp.

659. Boni, F., On the design of a liquid-metal-heated bayonet-tube steam generator, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-24, 14 pp.

The design considerations involved in a liquid-metal-heated bayonet-tube steam generator are discussed. The unit is characterized as a recirculation type and generates steam at subcritical pressures. Specific details in which thermal stresses have considerable effects are given. From author's summary

660. Clark, J. A., Arpaci, V. S., and Treadwell, K. M., Dynamic response of heat sources. Parts I, II, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-14, 11 pp.; ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-6, 9 pp.

Time behavior of circular tube temperature and coolant temperature which flows through it are analyzed for step change in rate of heat generation inside pipe wall. Constant fluid temperature and velocity across pipe axis, radially uniform tube temperature, negligible axial heat conduction, uniform heat-transfer coefficient and heat generation, constant inlet fluid temperature, adiabatic outside tube surface are assumed for mathematical analysis. Solutions of partial differential equations involve algebraically complicated functions which are given in graphs. Experimentally plotted temperatures are compared with theoretical predictions. Y. Takahashi, Japan

661. Farber, E. A., Solar water heating, present practices and installations, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-45, 8 pp.

662. Kostenko, G. N., The characteristics of heat exchange installations of periodic operation in reactors (in Russian), *Nauch. zap. Odessk. politekh. in-ta* **4,** 2, 131–139, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5988.

For nonsteady working steam jackets, coils, and other heat exchangers, a convenient method of evaluation is put forward by using some nondimensional characteristics. To illustrate this an example is given for the computation of a cooler of periodic operation, and the methods of increasing its efficiency are scrutinized.
Courtesy Referativnyi Zhurnal V. S. Zhukovskii, USSR
Translation, courtesy Ministry of Supply, England

663. Takahashi, Y., You need no computer to graphically determine the dynamics of heat percolation, *Control Engng.* **2,** 5, 46–50, May 1955.

Consider a pipe that transports a heating or cooling fluid. To perfect a thermal control system incorporating the pipe, the control engineer needs to be able to determine its outlet temperature transient response to inlet temperature change, internal flow rate change, variation in heat loss due to changes in external flow rate and external temperature distribution, and variation in parameters such as coefficients of heat transfer.

Mathematical analysis of the response, although possible, is difficult and tedious. However, the piecewise response to each disturbance can be constructed graphically. Programming accounts for nonuniformities and variations in parameters.

This article considers the outlet temperature response to only inlet liquid temperature change. A forthcoming article will show the generalized construction for the other disturbances.
From author's summary

664. Odel'skii, E. Kh., Investigations of hydraulic and heat regimes of local systems of heating in relation to the method used to connect them to heating networks (in Russian), *Sb. nauch. rabot Belorus. politekh. in-ta* no. 48, 47–61, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5916.

Investigations have been carried out on the cause for unsatisfactory performance and uncontrollability of local systems of space heating after their connection to the heat networks via a pump.

An analysis is made of hydraulic regimes of local systems of water-heating by the method of combining the hydraulic characteristics of the pump, the gravitational pressure, and the network. Author concludes that, in double-tube systems connected to the heating network via hydro-elevators, and, in consequence hydraulically bound with the main heating network, the possibility is excluded of increasing the quantity of the water being circulated by lowering the temperature of the outside air. This, in contrast to local double-tube systems with centrifugal pumps, leads to excess feed to the upper levels (thanks to the increase of active gravitational forces) at the cost of diminution of feed to the lower levels. In single-tube systems, connected to the heating network via elevators, the possibility is again excluded of increasing the volume of circulating water at the expense of the strengthening of the gravitational forces. But the dislocation of the feed at various levels by the raising of the temperature regime of the heat-carrier may not even arise if strict and correct standardization of the work of the heat-carrier is observed, in conformity with the heat loads. Author concurs in the expediency in all cases of independent schemes of normal type, in which the network water has no direct contact with the water circulating in the local system. Here, in addition to good adaptability of the systems to variable heat loads, there is simplification in connecting local systems with heating networks, the reliability of exploitation is increased, possibilities appear for increasing the temperature of the heat-carriers in the network and there is a marked lowering of requirements of feedwater on TETS. V. I. Polikovskii, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

665. Johnson, N. R., and Osterle, F., The influence of gradient temperature fields on thermocouple measurements, ASME-AIChE Heat Trans. Conf., University Park, Pa., Aug. 1957. Pap. 57-HT-18, 20 pp.

Expressions are derived for the error of a thermocouple bead immersed in a fluid stream having various temperature gradients along the wire. Authors neglect radiation, assume steady state, assume the wires uninsulated, assume the thermal conductivity of one wire so small compared to the other that it may be neglected, and make no mention of compressibility effects. The reader must assume that the authors are considering low-speed, low-temperature flow since no mention is made of recovery factors, total temperatures, etc. The effect of the simplifying assumptions on the final solution is considered briefly. It would have been interesting if the authors had compared their results with the classical hyperbolic cosine solution to the thermometer well problem.
R. J. Mindak, USA

666. Murphy, A. H., and Steven, G., Fast-response thermocouples using tubular hot-junction elements, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-1, 7 pp.

An investigation was conducted on the fabrication and testing of jet-engine thermocouples which combine fast response with adequate mechanical strength and resistance to vibration. Experimental data are presented which relate characteristic response time of the thermocouple to the dimensional variables of a tubular hot-junction element: tube diameter, wall thickness, and distance between supports. From authors' summary

667. Domenicali, C. A., Thermoelectric power and resistivity of solid and liquid germanium in the vicinity of its melting points, *J. appl. Phys.* **28,** 7, 749–753, July 1957.

The thermoelectric power of germanium against platinum has been measured between room temperature and 1030 C (melting point is 937 C). Five specimens were studied in the solid phase (three polycrystalline and two single crystalline specimens), and two in the liquid phase (one n type and one p type at room temperature). It is found that the absolute thermoelectric power Q of high purity (50–70 ohm-cm) germanium is nearly linear in $1/T$ only for the range $0.83 < (1000/T) < 1.5$, or $400 < T < 937$ C. The value of Q for our crystals at temperatures below 400 C is less negative than would be required by an extrapolation of the straight line $Q = +140 - 280(1000/T)$ μv/deg which represents fairly well the high temperature data. This discrepancy may be due to the presence of very small amounts of acceptor impurity (perhaps boron) in our crystals. The thermoelectric power between liquid and solid germanium is approximately 70 μv/deg, and the liquid is positive relative to the solid. The absolute thermoelectric power of the liquid is very nearly zero and is nearly independent of temperature. Finally, the resistivity of germanium decreases by a factor of approximately 19 upon melting, and is approximately 63 microhm-cm in the liquid phase. From author's summary

668. Pride, R. A., Hall, J. B., Jr., and Anderson, M. S., Effects of rapid heating on strength of airframe components, *NACA TN* 4051, 14 pp., June 1957.

Results of several experimental investigations are presented which indicate the effects of rapid heating on the bending strength of multiweb beams and ring-stiffened cylinders. It is shown that thermal stresses reduce the bending load carried at buckling by

both beams and cylinders. The influence of thermal stress on maximum load is found to depend largely on the mode of buckling. For beams that buckle locally, no apparent effect of thermal stress on the maximum load has been found. A reduction in maximum load has been observed for beams that buckle in the wrinkling mode and for cylinders. From authors' summary

Combustion

(See also Rev. 489)

669. Dooley, D. A., Ignition in the laminar boundary layer of a heated plate, Heat Trans. and Fluid Mech. Inst., Calif. Inst. Technol., Pasadena, Calif., June 1957, 321–342.

A theoretical analysis is presented of the ignition of combustible gas mixture in the laminar boundary layer established on a flat plate which was kept at a constant, higher temperature. The method leads to the iterative solution of the temperature and concentration profiles, in which great simplification is made by an assumption that both the Prandtl and the Schmidt numbers are equal to unity. Author indicates that the classical Prandtl boundary-layer assumptions would be invalidated in the region where the combustion front is fully developed, and that the results would be more accurate for the points extending from the leading edge to the point where the temperature of the boundary layer assumes the plate temperature.

A simple example of the thermal decomposition of azomethane ($C_2H_6N_2 \rightarrow C_2H_6 + N_2$) is presented, but no comparison with the experimental results is shown. H. Jinno, Japan

670. Bollinger, L. E., Strauss, W. A., and Edse, R., Burning velocities of Bunsen burner flames by the flame-pressure method, *Indust. Engng. Chem.* **49,** 4, 768–773, Apr. 1957.

Experiments were carried out to measure burning velocities by the flame-pressure method at a pressure of 14.6 atm. Results for hydrogen-oxygen flames were much smaller than those obtained earlier by the bunsen-burner method. A similar discrepancy of the results of both methods was observed with acetylene-oxygen mixtures at atmospheric pressure. It is concluded that burning velocities cannot be calculated from "flame pressures measured somewhere in the burner tube because of the radial escape of unburned gas through dead space." An improvement of the method is suggested by introducing the escape velocity into the theoretical relationship between flame pressure and burning velocity.

H. Behrens, Germany

671. Strubell, W., Some theoretical considerations on the problem of determination of flame propagation and flame velocity (in German), *Weltraumfahrt,* **8,** 2, 53–56, Apr. 1957.

The usual one-dimensional equations for conservation of mass and energy are written for a laminar flame. Approximations to simplify solution are discussed and compared with similar previous work. A simple relation between reaction rate, flame velocity, and flame thickness is derived. The relations are useful in estimating ignition energy and quenching distance. M. Gerstein, USA

672. Vrana, J. C., Progress in the development of a large residual fuel combustion chamber, *Nat. Res. Counc. Canad. mech. Engng. Rep.* MT-35, 7 pp. + 10 figs., Jan. 1957.

An all-metal chamber burning Bunker "C" fuel has been developed sufficiently to serve as a basis for the design of a satisfactory unit. Pressure drop and smoke efflux were found to be within satisfactory limits. The temperature profile is also satisfactory, but the lighting and control require a great deal of development.

From author's summary

673. Lewis, W. G. E., and Herbert, M. V., Aerodynamic factors in combustion chambers, *Engineering* **184,** 4769, 143–146, Aug. 1957.

The fundamental factors limiting combustion intensity assume importance when the space required for combustion in turbojet or ramjet engines becomes critical. Comparison of combustion data from typical turbojet and ramjet engines with data from the Longwell homogeneous reactor shows that limiting factors are related to the mixing processes rather than to chemical kinetics. Mixing in the dilution zone is related to pressure loss, and depends upon geometry. H. R. Hazard, USA

674. Wilson, E. S., John, R. R., and Summerfield, M., Spectroscopic studies of the effect of boundary layer flow on flameholding, *Jet Propulsion* **27,** 8 (part 1), 892–894, Aug. 1957.

A spectral intensity method for measuring the local fuel-air ratio in two-dimensional hydrocarbon-air flames is used to explore the phenomenon of preferential diffusion in the wake of bluff body flameholders. The findings support the hypothesis that turbulence in the boundary layer and in the adjacent flow reduces the degree of preferential diffusion and this, in turn, explains the observed shift in flameholder stability limits.

From authors' summary

675. Merk, H. J., Analysis of heat-driven oscillations of gas flows. I: General considerations, *Appl. sci. Res. (A)* **6,** 4, 317–335, 1957.

Author attempts to derive basis for theoretical treatment of such heat-driven oscillations as produce unstable combustion or noise in jet-engine combustors and rockets. Proceeding from equations of continuity, motion and energy as applied to a simplified model having a plane heat source, he shows that vibrations may be split into three modes; an acoustical and an entropy mode, both of which are irrotational while the former is isentropic, and a vorticity mode. The entropy mode is damped out very rapidly upstream from the heat source, so that this small thickness may be considered part of the heat source. A characteristic equation arises from applications of continuity conditions across the heat source. Real part of this characteristic equation produces instability criterion, while imaginary part determines frequencies at which instability sets in. M. A. Mayers, USA

676. Merk, H. J., Analysis of heat-driven oscillations of gas flows. II. On the mechanism of the Rijke-tube phenomenon, *Appl. sci. Res. (A)* **6,** 5/6, 402–420, 1957.

In part II, author considers Rijke-tube phenomenon (Lord Rayleigh, "Theory of sound"). Transfer functions are evaluated from published data as needed for insertion in equations of part I, simplified as permitted by simple physical system. Results agree with Carrier [AMR **8,** Rev. 2172]. In addition, a first-order solution of characteristic equation is obtained that accounts for features of the Rijke-tube phenomenon, that excitation occurs only when the heat source is in entrance half of tube, and that maximum excitation occurs when it is at about one fifth tube length from the entrance. M. A. Mayers, USA

Acoustics

(See Revs. 559, 675, 676)

Ballistics, Detonics (Explosions)

(See also Revs. 443, 551)

677. Tavernier, M. P., Theoretical internal ballistics (in French), *Mem. Artill. fr.* **31,** 2, 303–390, 1957.

This publication is a free translation from English into French of chapters IV and V of "Theory of the interior ballistics of guns" by J. Corner, Wiley, (1950). A review of Corner's book by J. P. Vinti was published in *Army Ordnance* **35,** p. 450, 1951; also AMR **4,** Rev. 3074.

A gun is a heat engine and motion of a shell inside a gun tube is controlled by a system of three differential equations: (1) energy balance equation, (2) Newton's equation of motion, and (3) equation of burning of the propellant. In chap. IV, author solves this system under the following simplifying assumptions: engraving resistence and shot-start pressure can be neglected and, by introducing an "effective" temperature, the kinetic energy term in energy equation can be removed. Author also assumes that the covolume equals the reciprocal of propellant density. These assumptions lead to a very simple solution which is a good first approximation. Chapter V gives more sophisticated solutions where some or all of the simplifying assumptions are removed.

T. Leser, USA

678. Hansen, M., Detonation and shock wave (in German), *Stahl u. Eisen* **77,** 12, 805–813, June 1957.

Elementary review of title subjects, followed by discussion of significance for blast-furnace practice. A number of explosions that occurred in steel plants are described; propagation of destructive effects along pipes to fairly distant points is cited as evidence for participation of shock or detonation waves.

G. H. Markstein, USA

679. Lawden, D. F., Maximum ranges of intercontinental missiles, *Aero. Quart.* **8,** 269–278, Aug. 1957.

The thrust magnitude program of a rocket missile being supposed specified, the problem is solved of programming the thrust direction to achieve maximum range on the earth's surface. Earth curvature and rotation, and variation of gravity with height are taken into account, but air resistance is neglected. Motion is assumed to take place in the equatorial plane. Tables are included from which the optimal trajectories of missiles may be computed when two design parameters are known, and these tables are used to assess the advantage to be gained at extreme ranges by firing in the sense of the earth's rotation rather than against it.

From author's summary

680. Tiger, B., and Brewington, W. H., Demonstrating system reliability by the sequential probability ratio test, *Jet Propulsion* **27,** 8 (part 1), 890–891, Aug. 1957.

The Sequential Probability Ratio Test is presented as a practical statistical approach to demonstrating the reliability requirements of rocket systems and subsystems. In this test, the sample size is not predetermined but, rather, the testing is continued and the results analyzed after each system is tested, until the results are sufficient to indicate a decision. The main advantages of this procedure are (a) a generally smaller sample size than that required by other statistical procedures, (b) all calculations can be done prior to testing and the test data can be recorded graphically without additional computations.

It is shown that the required calculations can be reduced to determining the equations of two straight lines. These two straight lines are then plotted on graph paper and the test results are recorded by a plot line on the graph. Testing is terminated as soon as this plot line intersects either of the straight lines. If the upper line is intersected, the system has not demonstrated adequate reliability and rejection is indicated. If the lower line is intersected, the system has met the reliability requirements and acceptance is indicated. From authors' summary

681. Schurmann, E. E. H., Optimum staging technique for multistaged rocket vehicles, *Jet Propulsion* **27,** 8 (part 1), 863–865, Aug. 1957.

In the preliminary design of multistaged rocket vehicles the question always arises as to whether the staging technique used is optimum. The purpose of this paper is to present a preliminary design method of determining the optimum staging under a known set of conditions. The simplifying assumptions that have been made are not too restrictive in that they are in line with most preliminary analyses. The results show that it is possible with a very few calculations to predict the optimum performance of a multistaged rocket vehicle. This procedure would be applicable to the design of ballistic missiles and satellite vehicles.

From author's summary

682. Harvey, T. J., Bending dynamics of a spinning missile, *Jet Propulsion* **27,** 6, 669–675, June 1957.

The effects of spin upon the bending of slender missiles with eccentric mass distribution are of great importance, particularly in the case of multistage missiles. The spin may be deliberately introduced for stabilization at launch or it may result from misalignment of the stabilizing fins. In either case the spin rate is time-dependent, and therefore the problem of determining these effects must be treated in a manner which is basically different from the usual "steady-state" calculations. The purpose of this paper is to present a method for calculating the bending moments which result from a nonsteady spin rate and the eccentricity of the center of mass axis.

The differential equations for the deflections are solved by expansion of the deflection of the bending neutral axis in a series of eigenfunctions of the body as a free beam. In this way, the variables are separated, and the time part of the solution is obtained using a digital computer.

A sample problem is included showing the method of calculating the bending moments for a nonuniform missile with a time-varying spin rate and a specified eccentric mass distribution.

From author's summary

Soil Mechanics, Seepage

(See Revs. 429, 430, 460, 683, 687, 688)

Micromeritics

(See also Revs. 414, 501, 525)

683. Nishida, Y., An estimation of the point resistance of a pile, *Proc. Amer. Soc. civ. Engrs.* **83,** SM2, (*J. Soil Mech. Found. Div.*), Pap. 1206, 12 pp., Apr. 1957.

Paper presents a new method, based on static considerations, for computing bearing capacity of foundation piles. Relationship between skin friction and point resistance is considered, those terms not being independent of each other. Theory of elasticity is used in approach, and Coulomb's law between skin friction and horizontal earth pressure is supposed to be valid. Numerical example shows good agreement with results obtained from load test. F. Correia de Araujo, Portugal

684. De Witte, A. J., Influence of differential displacement in invaded oil and gas sands on the induction log, *J. Petr. Technol.* **9,** 6, 48–50, June 1957.

685. Mehta, N. C., Smith, J. M., and Comings, E. W., Pressure drop in air-solid flow systems, *Indust. Engng. Chem.* **49,** 6, 986–992, June 1957.

A method for predicting solids flow rate in transport lines and fluidized systems satisfactorily handles air velocity, solids flow rate, and vertical and horizontal flow, but requires knowledge of particle velocity. From authors' summary

686. Tek, M. R., Development of a generalized Darcy equation, *J. Petr. Technol.* **9,** 6, 45-47, June 1957.

General equations relating the pressure drop necessary to sustain the flow of a fluid through a porous matrix at a given rate have been developed. The results indicate that at high values of flow rate the pressure-flow behavior may not necessarily satisfy the usual Darcy equation.

The mathematical analysis, carried through the micro-pore geometry and extended through the macro-reservoir scale, indicates that Darcy's law, of limited applicability to certain ranges of Reynolds numbers, can be generalized through the inclusion of some additional parameters.

The "generalized Darcy equation" has also been formulated in dimensionless form, permitting the evaluation of its predictive accuracy with regard to literature data.

A comparison between predicted and experimental values indicates that the generalized Darcy equation predicts the pressure drops with good agreement over all possible ranges of Reynolds numbers. From author's summary

687. Pykhteev, G. N., Filtration from a channel in the presence of two drains in a water obstructor (in Russian), *Izv. Akad. Nauk SSSR, Otd. tekh. Nauk* no. 6, 16-21, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5295.

Examination of the problem of plane symmetrical filtration from an infinitely fine channel, situated above a horizontal water obstructor in the presence of two plane drains on the latter. The motion is assumed to be steady and subject to the Darcy law, as a result of which the problem in question is reduced to a reverse mixed problem at values of the actual or imaginary part of the complex potential equal to zero or to a constant.

The general solution of the problem is given in closed form, which enables, in particular, the form of the free surface to be determined with the aid of numerical integration.

A detailed examination is made of the limiting case when the channel is infinitely remote from the water obstructor. In this case the calculation formulas are considerably simplified.

An approximate formula is constructed for determining the design of the free surface near a drain where the curve of depression coincides with the quadratic parabola with an accuracy equal to terms of the fourth degree. P. F. Fil'chakov, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

688. Surovtsev, B. P., Calculation of the filtration through earth dams on a foundation impervious to water (in Russian), *Dokladi Akad. Nauk Uz SSR* no. 9, 25-33, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5297.

On the basis of investigations on an E.G.D.A. instrument, author recommends empirical formulas for calculation of homogeneous earth dams. The calculation is based on "the specific resistance" of the flow fragments $R = \phi/k = \Delta H/Q$, where ϕ is the modulus of the form of the fragments and k the filtration coefficient. Empirical formulas are given for determination of ϕ for the upper and lower wedge; these give results which do not completely coincide with those obtained by the abstractor from the analysis of hydromechanical solutions [*Gidrotekhnika i melioratsiya* no. 1, 1952]. Further, the calculation method suggested is generalised by the usual means to dams with a core (author does not indicate the discontinuity of the depression curve at the exit from the core). Filtration in dams with a screen highly impervious to water is also examined. G. K. Mikhailov, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

689. Teplitskii, I. S., Application of the operational method to some problems of unsteady filtration (in Russian), *Trudi in-ta matem. i mekhan. Akad. Nauk Uz. SSSR* no. 15, 123-130, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5306.

The operational method is applied to the solution of problems of the unsteady motion of soil waters. The equation of unsteady motion is converted into a Laplace equation for the representation. It is shown that if each section of the boundary is rectilinear, then, in the region of the complex potential for the representation, the boundary of the region will also consist of rectilinear sections. Therefore, reflection is found with the aid of the Christoffel-Schwarz integral. The case of the presence of a free surface is not considered. An example is given of the application of the method to an actual problem of filtration under a plane spillway on an unlimited foundation. V. K. Belyakova, USSR

Courtesy Referativnyi Zhurnal

Translation, courtesy Ministry of Supply, England

690. Pirverdyan, A. M., Expulsion of petroleum from a porous medium by water (in Russian), *Trudi Azerb. n.-i. in-ta po dobyche nefti* no. 1, 269-285, 1954; *Ref. Zh. Mekh.* 1956, Rev. 5307.

By analogy with deficiency equations of filtration of a gassed liquid, corresponding equations are introduced for a two-liquid mixture (water and petroleum); it is assumed that the liquid (water), which is an analog of the gas, is incompressible and has a solubility coefficient of zero. The equations suggested are used for solving problems of the one-dimensional expulsion of the mixture at a given discharge to a rectilinear gallery and to a circular crevice. In the solution of these problems it is assumed that effective permeability of the seam in respect of separate components of the mixture is a function of the hydrodynamic pressure alone.

On the basis of the assumption of the theory of mechanical similarity the more general laws of velocity of a two-liquid incompressible mixture in porous media are examined. For this case, certain views are given regarding the possible solution of differential equations of motion of a two-dimensional mixture.

It is pointed out that in the author's formulas the gradient p has not a vector but a scalar value.

Courtesy Referativnyi Zhurnal V. P. Pilatovskii, USSR

Translation, courtesy Ministry of Supply, England

691. Salekhov, G. S., Statement and method of solving hydrodynamic problems of control of the motion of a petroleum-bearing contour (in Russian), *Izv. Kazansk. fil. SSSR, Ser. fiz.-matem. i tekhn. Nauk* no. 6, 3-38, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5308.

A general statement and a solution of the problem of control of motion of a petroleum-bearing contour is given. Putting $r = f(\phi, t)$ as the practically desirable law of contraction of the contour, author determines the discharge and position of the crevices which best insure the law of contraction of the petroleum-bearing contour. In order to obtain the basic system of equations, the theory of approximation by trigonometric polynomials of the function ϵ in the right-hand portion of the equation of motion was used

$$m\frac{\partial r}{\partial t} - \frac{k}{\mu}\frac{1}{r^2}\frac{\partial r}{\partial \theta}\frac{\partial p}{\partial \theta} + \frac{k}{\mu}\frac{\partial p}{\partial r} = \epsilon(Q_i, \rho_i, \varphi_i, r, t) \qquad [1]$$

Expending the function ϵ into a Fourier series relative to θ and making equal to zero the Fourier coefficients M_i which also do not become zero, author obtains a system of equations for unknown

values of Q_i, ρ_i, φ_i. In virtue of Parseval's equation, the mean quadratic error may be assessed according to the formula

$$I_N = \left(\frac{1}{2\pi}\int_0^{2\pi} \epsilon^2 d\theta\right)^{1/2} = \left(\frac{1}{2}\sum_{k=M+1}^{\infty} [A_k^2 + B_k^2]\right)^{1/2} \qquad [2]$$

while in formula [2] instead of the values Q_i, ρ_i, φ_i ($i = 1, 2, 3, \ldots, n+1$) the values which should be inserted are those found from the solution of the basic system.

The basic system was obtained in a closed form for a homogeneous horizontal seam of constant power with the circular law of contraction of the petroleum-bearing contour.

Later, an examination was made of several cases of control of motion of a petroleum-bearing contour according to the character of operation: (1) Two operational crevices, (2) one operational and one delivery crevice, (3) three operational crevices, (4) two operational and one delivery crevice, (5) two delivery and one operational crevice, (6) two operational batteries of n crevices in each battery, (7) one operational and one delivery battery of n crevices in each. A solution of the problem for rectilinear batteries was obtained by a limiting transition.

For each of the cases indicated, a relationship was found between the relative discharge flows, having regard to the condition of law determination of the discharges.

Courtesy Referativnyi Zhurnal V. Yu. Kim, USSR
Translation, courtesy Ministry of Supply, England

692. Chugunov, V. D., Some particular cases of control of the advance of a water-petroleum contact (in Russian), *Izv. Kazansk. fil. Akad. Nauk SSSR, ser. fiz.-matem. i tekhn. nauk* no. 6, 39–52, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5309.

An examination of the problem of control of motion of a petroleum-bearing contour in G. S. Salekhov's arrangement [see preceding review] for cases of three circular and rectilinear batteries.

The relative values of the discharges of crevices were found in batteries (as functions of the initial angles of reading) on the condition that the crevices in the batteries are placed at identical distances from one another. Author shows the presence of several cases of the optimum location of crevices which are obtained as a result of displacement of one battery relative to two others. Graphs of the relationships of the discharges of the delivery crevice with the lapse of time are given.

Courtesy Referativnyi Zhurnal V. Yu. Kim, USSR
Translation, courtesy Ministry of Supply, England

693. Barenblatt, G. I., On certain questions concerning the theory of the movement of suspended particles in a turbulent flow (in Russian), *Vest nik Mosk. un-ta* no. 8, 54–56, 1955; *Ref. Zh. Mekh.* 1956, Rev. 6054.

M.A. Velikanov's observations on the author's work are considered. Giving views opposed to the deductions of Velikanov regarding the work of suspension in the equation for the energy of the neutral movement, author indicates that in his theory this value is not introduced arbitrarily into this or that equation, but, it appears, enters the equation of the balance of pulsation energy as the result of the derivation of that equation from the general equation of the mechanics of uniform media.

It is shown that from the inequality

$$|\,(\overline{u'v'})\ disp.\,| < |\,(\overline{u'v'})\ homogen.\,|$$

M.A. Velikanov incorrectly obtained the inequality

$$(\overline{du'v'/dy})\ disp. < (\overline{du'v'/dy})\ homogen.$$

Considerations are put forward regarding the hypotheses of A.N. Kolmogorov in relation to the values characterizing the turbulent transport to the possibility of disregarding the viscous transports of turbulent energy, and to other matters touched on in the memorandum of M.A. Velikanov.

M. A. Velikanova and B. A. Fidman, USSR
Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

694. Kunetz, G., and Chastenet de Gery, J., Conformal mapping and potential theory in problems with composite media of unequal permeabilities (in French), *Rev. Inst. fr. Petrole et Ann. Com. Liq.* **9**, 10, 1179–1192, 1956.

The mathematical principles of conformal mapping are outlined. The method is then applied to several two-dimensional problems involving composite media made up of two or more homogeneous media of differing permeabilities, and separated by interfaces of various shapes. The principal cases covered are a vertical fault, a valley or anticline, a double wave in the strata, and a buried anomaly (such as a dome). The immediate application intended is in earth-current prospecting, but flow through porous media is also included. C. F. Bonilla, USA

695. Cruise, A. J., Microscopic dust: Sampling methods can affect size estimations, *Engineering* **185**, 4750, 366–368, Mar. 1957.

Possible relationships between concentrations of microscopic particles in both urban and industrial atmospheres, and respiratory diseases and disabilities, have led to a growing interest in the problems of airborne particulate matter. In this article the deposition patterns of dust particles are examined, and their effect on different sampling methods discussed.

From author's summary

696. Ranz, W. E., Principles of inertial impaction: A survey of information applicable to an analysis of mist and dust collectors, Pennsylvania State Univ., Dept. Engng. Res., Bull. 66, 41 pp., Dec. 1956.

Author presents an organized summary of the theoretical analysis of the impaction efficiencies of a number of basic flow systems which can be used to describe most types of inertial separation equipment. Graphical results are given for a number of wall collectors and body collectors. Several dimensionless variables are introduced, and a number of generalizations concerning the properties of inertial impaction systems are made in terms of these variables. This paper should be of value to those concerned with the design of mist and dust collection devices.

G. C. Wallick, USA

697. Mori, Y., and Ototake, N., On the viscosity of suspensions (in Japanese), *Chem. Engng. Japan* **20**, 488–494, Sept. 1956.

Taking into account the consideration reported in *J. Phys. Colloid Chem.* **53**, 1949, by Robinson, and the observation by Bingham, authors have derived the following theoretical relationship for the relative viscosity of general suspension systems.

$$\eta_r = 1 + \frac{\bar{d}\,S_r}{2\Phi},\quad \Phi = \frac{1}{\varphi_v} - \frac{1}{\varphi_{vc}} \qquad [1]$$

where $\bar{d}$ is the effective average diameter of particle, S_r the volume specific surface, φ_v the volume concentration, and φ_{vc} the limiting concentration at the full-packed state, where steady flow can occur without any deformation, fracture, or grinding of particles. $\frac{\bar{d}S_r}{2}$ is a function of particle shape, whose value becomes 3 for sperical particles, and φ_{vc}, the limiting concentration, may be a function of the particle shape and its size distribution. In special case when the suspended particles are spherical and have equal size, the obtained formula becomes as follows, pro-

vided the value of φ_{vc} is assumed to be equal to 0.52, which is the volume fraction of solid in cubic packing of spheres of equal size.

$$\eta_r = 1 + \frac{3}{(1/\varphi_v) - (1/0.52)} \qquad [2]$$

This formula agrees quite well with the observed values given by different writers over a wide range of concentration.

For the systems composed by two different sizes or diverse particles, original equation [1] was confirmed by experimental results, for example, given by Eveson Ward and Whitmore for the suspensions consisting of polymer spheres in organic solution and others. From authors' summary

698. Laursen, E. M., The application of sediment-transport mechanics to stable-channel design, *Proc. Amer. Soc. civ. Engrs.* **82,** HY 4 (*J. Hydr. Div.*), Pap. 1034, 11 pp., Aug. 1956.

699. Bracale, S., and Cabella, A., On the mechanism of fluidization of the solid-gas system (in Italian), *Ric. sci.* **27,** 5, 1448–1455, May 1957.

In the first part of the paper a critical analysis is made of the interpretation of other writers on the mechanism of fluidization with respect to the degree of homogeneity of the fluidized bed. The authors of this work had previously presented experimental evidence in the form of a friction factor-modified Reynolds number plot which showed uniform distribution of solids in a baffled fluidized bed.

The experimental portion of the work consists in measuring the static pressure at various heights in a baffled fluidized bed. From the fact that the pressure drop per unit of height is constant over the height of the column they conclude that a homogeneous solid dispersion exists in the column. They also observe that the operable range of the gas velocity in the baffled bed extends to double that achievable in the unbaffled bed operation.

From authors' summary

Geophysics, Meteorology, Oceanography

(See also Revs. 399, 585, 597)

700. Iwasa, Y., Attenuation of solitary waves on smooth bed, *Proc. Amer. Soc. civ. Engrs.* **83,** HY3, (*J. Hydraul. Div.*), 15 pp., June 1957.

The hydraulic characteristics of solitary waves have been considered earlier. In this paper, further development of the study of solitary waves is treated. Especially considered is the mathematical analysis of the attenuation process of solitary waves. The theoretical results are compared to experimental data of Russell and Ippen.

It should also be noticed that the total kinetic energy minus the potential energy is twice the amount of the kinetic energy of the vertical motion, as Starr has already verified.

From author's summary

701. Woodcock, A. H., Salt and rain, *Sci. Amer.* **197,** 4, 49 pp. + 9 figs, Oct. 1957.

Recent studies indicate that particles of salt from the sea may play a key role in the process of a small water droplet in a cloud growing into a large raindrop. Clouds float high in the air, and the cloud droplets fall so slowly that they evaporate before reaching the ground. To come down as raindrops, the cloud droplets must grow to drops that fall about 20 times faster. Under right conditions, 10,000 cloud droplets per cubic inch will combine into one rain drop per 10 cubic inches. Two theories exist for explaining this process. One is the ice-crystal theory of Bergeron and Findeisen, according to which the cloud droplets in the cold upper region of a high cloud exist in a supercooled state; if ice crystals are present they evaporate the droplets, and then absorb the vapor; the ice crystals, feeding on the cloud droplets, may grow to large size and then fall as snow or melt to rain. On this theory is based the artificial rain-making by means of dry ice and other crystals (Langmuir and Schaefer).

According to the second theory, the large particles in clouds grow into raiadrops by sweeping up the smaller droplets, in a manner similar to a rolling drop of mercury gathering up any mercury drops it encounters. Author's group investigates the possibility that the rain-gathering giant nuclei are salt particles from the sea. Ordinary sea winds carry from 10 to 100 pounds of sea salt per cubic mile of air. Author sampled salt in atmosphere with glass slides, in airplanes traveling at various heights. Method of taking the samples and evaluation of the slides is described. Bubbles forming on the whitecaps of waves are believed to be the source of sea-water droplets in the winds over the sea. It was also found that these droplets are electrified, which may account, at least partly, for the electrification of the atmosphere.

K. J. DeJuhasz, Germany

702. Deacon, E. L., Sheppard, P. A., and Webb, E. K., Wind profiles over the sea and the drag at the sea, *Austr. J. Phys.* **9,** 4, 511–541, Dec. 1956.

Wind speeds were measured at heights up to 13 m over the sea by means of anemometers mounted on a mast attached to the jib-boom of a small vessel and another on the foremast cross-trees. The vertical temperature gradient and air/sea temperature differences were also observed. On some occasions, wind and temperature structures were explored up to 80–100 m by kite balloon.

A method of observation was devised whereby the effect of the ship's hull on the wind speeds was eliminated, and, from the corrected profiles, surface drag coefficients were calculated. For neutral conditions and fetch of wind over the sea of 20–40 km it is found that the drag coefficient (for 10 m reference height) is about 0.0010 in light winds, rising to about 0.0021 at wind speeds from 10 to 15 m/sec.

The drag coefficient is probably rather sensitive to stability variations, increasing particularly in the direction of instability, but the effects of variation in fetch of the wind over water are much less evident. In proximity to shallow water, the drag coefficient increases appreciably. From authors' summary

703. Dryden, W. A., Effects of the scale of spatial averaging on the kinetic energies of small-scale turbulent motion, *J. Meteor.* **14,** 4, 287–292, Aug. 1957.

The results of an experimental technique developed by Miller [*Geophys. Res. Pap.* no. 19, 294–301] involving continuous stereoscopic photography of the field of motion of lint particles have been employed by author to evaluate the effect of spatial averaging on the kinetic energies of small-scale air motions. Earlier studies had been concerned with the easier problem of evaluating effects due to the use of various temporal averages. The volume used in the experimental program was divided into subvolumes according to four different scales such that volume ratios of 1:64, 1:16, 1:8, and 1:4 were obtained. Overlapping volumes were required for the last three scales. The observed positions and motions of each particle having trajectories in the subvolume under consideration were then used to compute the average velocities and then the kinetic energies of the air motion in that subvolume. Since instantaneous air velocity may be resolved into mean and eddy velocity components, author reasons that, as the size of an averaging volume is decreased, the average velocity at a point in the volume will approach the instantaneous velocity, or that the eddy velocity will approach zero.

Hence, the mean velocity (and the kinetic energy of mean motion M) should decrease and the eddy velocity (and the mean kinetic energy of eddy motion E) should increase as the scale of the spatial averaging increases.

Although the assumption of a constant total kinetic energy K did not hold true for the computations, it was shown from the various streamline and isotach patterns that the relative kinetic energies, $E/\overline{K}$ and $M/\overline{K}$ did behave as author predicted and that each ratio tended to approach limiting values. Reviewer believes that this is a significant contribution to the analysis of turbulent motions in that it vividly demonstrates the dependence of the value of turbulence properties on the averaging scale which is employed.

J. R. Gerhardt, USA

704. Ogura, Y., Spectrum modification due to the use of finite differences, *J. Meteor.* **14,** 77–80, Feb. 1957.

In forecasting the weather numerically, differential equations are replaced by finite difference equations. Author demonstrates that the vorticity computed from the finite difference formula depends upon the size of the grid being used, and the energy spectrum is effectively multiplied by an influence function which decreases rapidly with increasing wave number. For not too large wave numbers, it is found that the "−5/3 power law" is a good approximation for the energy spectrum of the atmospheric motion.

H. L. Kuo, USA

705. Haarlander, H., Quasigeostropic theory of nonstationary pressure fields in a baroclinic atmosphere with surface friction (in German), *Meteor. Rdsch.* **9,** 9/10, 158–164, Sept./Oct. 1956.

Extending researches initiated by G. Hollmann, this paper attempts to formulate what is essentially a linear stability analysis of a quasi-geostrophic baroclinic atmosphere with surface friction. Assuming an equivalent barotropic atmosphere above some unspecified level, Haarlander approximates the flow in the lower layer by the Brunt-Douglas equation, but also incorporating a frictional force proportional to the velocity itself. Combining these two equations leads to a single differential equation in the isobaric height, for which a wave form is assumed, a function of three dimensions and time. Under quasi-geostrophic and hydrostatic conditions, the fields of temperature, vertical velocity, and adiabatic heating can be expressed in terms of this solution. The stability analysis is extremely sensitive to the frictional coefficient and to the assumed dependence on the north-south coordinate. Since the results do not reduce to the usual ones in the absence of friction, and since the representation thereof is highly artificial, it is difficult to interpret the results physically.

M. Wurtele, USA

706. Sugii, A., Application of matrix as an operator to meteorology, *Geophys. Mag., Tokyo* **27,** 3, 353–360, Sept. 1956.

Author tries to characterize the field of meteorological elements with the values at grid-points, when the meteorological elements are distributed two-dimensionally and change with time. These values at grid-points are represented by the matrix and extrapolated. As an example, this method is applied to the extrapolation of the 5-day mean of 700-mb heights. In this way, two fields of the 5-day mean of 700-mb heights are analysed: fields of zonal and meridional gradients of mean 700-mb heights. A numerical example using the data of October 1953 is shown.

From author's summary

707. Dyunin, A. K., On the distribution of the discharge of a blizzard flow according to altitude (in Russian), *Trudi Transp.-energ. in-ta Zap.-Sib. fil. Akad. Nauk SSSR,* no. 4, 49–58, 1954; *Ref. Zh. Mekh.* 1956, Rev. 6068.

Based on the work of V. N. Goucharov on the migration of particles in a stream, and on some assumption of the distribution of the longitudinal velocities of the stream, author derives a theoretical profile of the solid output, which clearly shows the maximum at a certain, not very small, distance from the earth's surface, qualitatively meeting the nature of the phenomenon. The quantitative coincidence of the curve with the given dimensions, in conformity with the applied graphs, may be taken as satisfactory.

Courtesy Referativnyi Zhurnal M. A. Velikanov, USSR
Translation, courtesy Ministry of Supply, England

Lubrication; Bearings; Wear

(See also Rev. 615)

708. Taylor G., and Saffman, P. G., Effects of compressibility at low Reynolds number, *J. aero. Sci.* **24,** 8, 553–562, Aug. 1957.

Positive pressures were observed by Reiner at the center of the air gap between two disks less than 2 microns apart, when one was rotating at high speed. This was attributed to a non-Newtonian or viscoelastic property of air, demonstrating an elastic shear behavior in air.

This paper attempts to explain the observation as being due to geometrical and dynamical imperfections of the apparatus. Starting from Stewartson's solution of Navier-Stokes equation for low *Re* numbers, authors show that, if the fluid is considered incompressible, such imperfections cannot be the cause of the observed pressure rise. Authors then analyze the problem for a compressible fluid and show that positive mean pressures can be caused. Although the analytical treatment involves a number of approximations, the results are convincing and demonstrate that even at very low Mach numbers the effect of compressibility may be very important.

But since Reiner's theory is contrary to accepted theory—it would invalidate Navier-Stokes equation and could not be explained by the kinetic theory of gases—and the explanation of the authors is so convincing, reviewer believes that further investigations are warranted; in particular a positive experimental proof of the explanation as given by the authors.

These investigations, apart from clarifying the basic issue, are of interest in connection with air-lubricated bearings.

A. J. Raudkivi, New Zealand

709. Shires, G. L., On a type of air lubricated journal bearing, *Aero. Res. Counc. Lond. curr. Pap.* 318, 30 pp. + 14 fig., 1957.

Experimental performance of hydrostatic air journal bearings is correlated with a nondimensional parameter based on theory of viscous flow in a narrow slot. Effects of rotation are found to be negligible at peripheral speeds to 100 ft/sec.

W. J. Anderson, USA

710. Guilinger, W. H., and Saibel, E., The effect of heat conductance on slider-bearing characteristics, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-90, 19 pp.

Authors attempt to show how the rather complicated equations describing the aforementioned effect can, by neglecting the terms of the smallest orders of magnitude, be simplified to such an extent that they become tractable, at least for computers. However, there is obviously an error in their assumption that one of the two terms in their continuity equation [1] may be neglected. In fact, this equation implies that both terms must be of exactly the same order of magnitude. Another objection is that the thermal boundary conditions (29) and (30) refer to Newton's law of cooling, instead of accounting for the fairly generally recognized fact that there is no temperature jump between a liquid and a bounding, solid surface.

H. Blok, Holland

711. Weiter, E. J., and Schmidt, A. O., Coefficients of friction of flat sliders, ASME Semiann. Meet., San Francisco, Calif., June 1957, Pap. 57-SA-100, 20 pp. + 14 figs.

712. Baudry, R. A., Kuhn, E. C., and Wise, W. W., Influence of load and thermal distortion on the design of large thrust bearings, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-73, 12 pp.

713. Baudry, R. A., Peterson, G. E., and Cooper, G. D., Oil seals to provide positive lubrications on large or high-speed thrust bearings, ASME Semiann. Meet., San Francisco, Calif., June 1957. Pap. 57-SA-74, 8 pp.

Marine Engineering Problems

(See also Revs. 393, 655, 702, 718)

714. Golovato, P., The forces and moments on a heaving surface ship, *J. Ship Res.* **1**, 1, 19–26, 54, Apr. 1957.

As a first part of a comprehensive investigation for motions of ships in a seaway at the Taylor Model Basin, a ship model (with mathematical lines defined by Weinblum) was constrained to heave at various speeds, periods, and amplitudes in harmonic oscillations. Analyzed test data yield frequency, speed, and amplitude dependence of the added mass and damping and the cross-coupling moments (including nonlinear effects). Practicality of this investigation is obvious. The interesting results are critically examined and referred to theoretical work by Ursell, Grim, F. M. Lewis, Prohaska, Havelock, Haskind, and Korvin-Kroukovsky, and to experiments by Haskind and Riman. H. Thieme, Germany

715. Meyer, E. R., Model test results for Saunders ABC ships, models 4505 and 4505-1, *David W. Taylor Mod. Basin Rep.* 1006, 37 pp., Feb. 1957.

Report contains the results of a complete model testing program on a unique design of a 510-ft passenger-cargo vessel. This design embodies two alternative hull forms, using single-screw propulsion. The forebody is the same for each form and features a large ram-bulbous bow. The afterbody of one has a transom stern with a centerline skeg; the second has an arch or tunnel stern with double skegs.

The model test program included resistance tests with and without appendages, self-propulsion tests, wake survey, lines of flow and wave-profile test, flow studies in the circulating water channel, change-of-level readings, and determination of bilge keel trace. The results of these tests are presented in graphical form.

The hull form with the transom stern gave excellent performance. It has several distinct advantages and can compete successfully with the normal cruiser-stern-type merchant ship. The performance of the arch or tunnel stern vessel was satisfactory for its type, but did not equal the efficiency of the transom stern. This form may be useful for special types of services.

From author's summary

716. Hinterthan, W. B., Report on geosim analysis according to Schoenherr line, *David W. Taylor Mod. Basin Rep.* 1064, 88 pp., July 1956.

Report deals with the compilation and analysis of geosim resistance data for use by the Skin Friction Committee of the International Towing Tank Conference in its search for a new "engineering" friction line. In determining the "engineering" friction line careful considerations were given to some important points with a view to coordination between model basins to reach international agreement. From author's summary

717. Belgaumkar, B. M., Vibration troubles in ships, Presented at Best Conference Hall of the Inst. of Marine Technologists, 36 pp., Feb. 1956.

Paper deals with the development of the study of vibration in brief, then a discussion of the general nature of vibration, mathematical details being avoided wherever possible. The types of troubles experienced due to vibration in the hull, the propeller shaft, and the propeller blades, with the nature and sources of vibration in each case, and also remedies, if any, to reduce or eliminate vibration have been reviewed. A reference is made to the author's contribution to anological methods in the study of vibration. A short survey is given of the instruments developed and used in the experimental study of vibration in ships. Finally in the concluding remarks, attention is drawn to the importance of study of "slam"—its nature and effects. Acknowledgements and a list of references are given at the end.

From author's summary

718. Kutyanin, P., Problem of methods of calculating the speed of movement in the propulsion of vessels (in Russian), *Mor. i rechnoi flot.* no. 12, 7–11, 1954; *Ref. Zh. Mekh.*, 1956, Rev. 5212.

In the course of the discussion, a calculation of the velocity of motion of propelled vessels is suggested which does not require revision of the operational and technical characteristics of steam and diesel vessels available in steamship companies. In addition to the calculation formulas, a supplementary nomogram is constructed which facilitates the determination of correction coefficients used in the calculation. Numerical examples are given.

S. N. Blagoveshchenskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

719. Miroshnichenko, I., Determination of the fullness coefficient of displacement for large tankers (in Russian), *Mor. flot.* no. 10, 24–27, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5209.

Static data are given on vessels of the tanker fleet built abroad in the period 1951–1954, and also the results of tests made in the U.S.A. of ten power-driven models of tankers. On the basis of the analysis of this material a conclusion is given relating to the rational choice of the fullness coefficient of the water displacements. In particular, it is pointed out that for heavy tonnage tankers with a Froude number of 0.20 to 0.21 it is more advantageous to increase the load-carrying capacity at the cost of increasing the coefficient δ, taking this value to 0.77 to 0.78, than to reduce this coefficient, thereby reducing the residual resistance in order to obtain an increase of power. A. A. Kostyukov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

720. Nekhzer, A., On the influence of the differential settling on the stability of the vessel (in Russian), *Mor. flot.* no. 4, 17–19, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5960.

The necessity is shown for calculating the influence of the differential settling of the ship on the elevation of its center of size above the basic plane when determining the position of the center of gravity of the ship experimentally.

A determination is made of the margin of error when the differential settling is miscalculated, which may amount to the size $\Delta z_c = 0.18m$, when the longitudinal radius of the metacenter $R = 100m$ and the differential angle of the ship $\phi = 0.06$.

A scheme is given for calculating the corrections required to determine the influence of the differential settling of the stability of the ship. S. N. Blagoveshchenskii, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, England

721. Litovchin, B. D., Problem of dynamic stability in respect to lateral roll (in Russian), *Nauch. tr. Odessk. in-ta inzh. mor. flota* no. 2, 200–208, 1954 (1955); *Ref. Zh. Mekh.* 1956, Rev. 5216.

Examination of the problem of determining the minimum transverse metacentric height at which a vessel will satisfy the standards of roll stability. The cases are examined in which the heeling of the vessel is limited and not limited by the entry into the water of hull openings.

The relationship is determined between the known diagrams of static and dynamic stability for a vessel in an unsatisfactory state and an unknown diagram of the arms of the dynamic stability which corresponds to the required metacentric height. This relationship is expressed by a transcendental equation. A graphical method is suggested for solving this equation, and a calculation procedure is laid down. A. A. Kostyukov, USSR

Courtesy Referativnyi Zhurnal
Translation, courtesy Ministry of Supply, USSR

722. Remez, Yu., A universal diagram for the determination of the influence of the course and speed of the ship on its rolling (in Russian), *Mor. flot.* no. 10, 18–20, 1955; *Ref. Zh. Mekh.* 1956, Rev. 5958.

A diagram is given which gives a picture in graphical form of the known relationship between the apparent wave periodicity, its length, speed and angle to the course of the ship. The diagram enables rapid determinations to be made of the significance of the length of the wave, causing the ship to roll, and also the speed and course angle of the ship; in which circumstances resonance sets in, both in rolling and pitching of the ship.

Courtesy Referativnyi Zhurnal A. A. Kostyukov, USSR
Translation, courtesy Ministry of Supply, England

723. Gigg, R. V., Kurn, A. G., and Friswell, J. K., Towing tank tests to determine the water drag of the hull of a jet propelled flying boat fighter (Spec. E. 6/44) and comparison with full scale measurements, *Aero. Res. Counc. Lond. curr. Pap.* 284, 17 pp. + 1 fig., 1956.

The water drag, draught, wetted areas, and mean wetted lengths of a 1/9th scale E. 6/44 flying boat model hull have been measured for all anticipated take-off loads and attitudes over the take-off run.

A method of scaling up model drag, to make allowances for the differences in skin friction, model and full scale, has been used and the results compared with actual full-scale tests.

There is not satisfactory agreement between estimated and measured full-scale results, and the tests do not provide sufficient evidence to determine whether the accurate estimation of full-scale water resistance by the methods used is possible.

From authors' summary

724. O'Brien, T. P., Some effects of blade thickness variation on model-screw performance, *N. E. Cst. Instn. Engrs. Ship. Trans.* **73,** part 7, 405–448, May-June 1957.

Tests with two sets of 10-in. diam model screws, each set comprised of 4 screws, are reported upon. One set had segmental sections at outer radii, airfoil sections at inner radii, while second set had segmental sections at all radii. Screws were tested in open water and in water tunnel. Calculations were made for comparison. Calculations according to Burrill and Hill and Troost B 4 chart show satisfactory agreement for first set with normal blade thickness, but agreement with tests is not so good. Hill factors show better agreement with tests of second set than Ludwieg-Ginzel factors. Troost B-4-55 screws require 12% pitch reduction at optimum diameter with 100% thickness increase. Optimum diameter is reduced 10% with 100% thickness increase. Thicker sections show earlier thrust breakdown with cavitation, but are not associated with adverse towing performance under cavitating conditions. Effects of increased blade thickness with segmental sections are more marked than with airfoil sections.

G. Vedeler, Norway

Letters to the Editor

725. Concerning AMR 10, Rev. 3360 (October 1957): Gurle, N., On hydrodynamic stability in unlimited fields of viscous flow,

Author's name should read Curle, N., instead of Gurle, N. in the review and also in the authors' index. The editors regret this error.

726. Concerning AMR 10, Rev. 3260 (October 1957): Hu, H.-C., and Shi, P.-M., On the equilibrium and stability of elastic thin-walled cylinders, Scientia Sinica 5, 2, 185–204, June 1956.

The authors' names were given as Hai-Chang, H. and Po-Ming, S. instead of Hu, H.-C. and Shi, P.-M. The editors regret this error.

Books Received for Review

ATKIN, R. H., Mathematics and wave mechanics, New York, John Wiley & Sons, 1957, xv + 348 pp. $6.00.

BALLY, R. J., Metode electrice de imbunatatire a paminturilor in lucrarile de constructie, Editura Academiei Republicii Populare Romine, 1957, 246 pp.

BUCKINGHAM, H., and PRICE, E. M., Principles of electrical measurements, New York, Philosophical Library, 1957, xxiii + 600 pp. $4.75.

SHERA, J. H., KENT, A., and PERRY, J. W., edited by, Advances in documentation and library science, II: Information systems in documentation, New York, Interscience Publishers, xix + 639 pp. $12.00.

Strain gage techniques, presented at MIT and UCLA, 1957, Part I: viii + 320 pp.; Part II: viii + 657 pp.

Umanskii, A. A., Statika i kinematika ferm, Moscow, Gosudarstvennoe Izdatel'stvo Tekhniko-Teoreticheskoi Literatury, 1957, 339 pp.

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